PROCEEDINGS

OF THE

IOWA ACADEMY OF SCIENCES

FOR 1903

VOLUME XI

EDITED BY THE SECRETARY

PUBLISHED BY THE STATE

DES MOINES:
B. MURPHY, STATE PRINTER
1904

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LETTER OF TRANSMITTAL.

DES MOINES, IOWA, July 5, 1904.

To His Excellency, ALBERT B. CUMMINS, Governor of Iowa:

SIR—In accordance with the provisions of Title 2, chapter 5 section 136, Code 1897, I have the honor to transmit herewith the proceedings of the eighteenth annual session of the Iowa Academy of Sciences.

Respectfully submitted.

T. E. SAVAGE,
Secretary Iowa Academy of Sciences.

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*Paper omitted from this volume on account of lack of space.

OFFICERS OF THE ACADEMY.

1903.

President—B. Fink.
First Vice-President—S. W. Beyer.
Second Vice-President—Maurice Ricker.
Secretary—A. G. Leonard.
Treasurer—H. W. Norris.

EXECUTIVE COMMITTEE.

Ex-Officio—B. Fink, S. W. Beyer, Maurice Ricker, A. G. Leonard, H. W. Norris.

Elective—L. H. Pammel, C. O. Bates, G. E. Finch.

1904.

President—B. Shimek.
First Vice-President—L. H. Pammel.
Second Vice-President—M. F. Arey.
Secretary—T. E. Savage.
Treasurer—H. W. Norris.

EXECUTIVE COMMITTEE.

Ex-Officio—B. Shimek, L. H. Pammel, M. F. Arey, T. E. Savage, H. W. Norris.

Elective—H. E. Summers, C. N. Kinney, G. E. Finch.

PAST PRESIDENTS.

Osborn, Herbert	1887-88
Todd, J. E	1888-99
Witter, F. M	1899-90
Nutting, C. C	1890-92
Pammel, L. H	1893
Andrews, L. W	1894
Norris, H. W	1895
Hall, T. P.	1896
Franklin, W. S	1897
Macbride, T. H	1897-98
Hendrixson, W. S	1899
Norton, W. H.	1900
Veblen, A. A.	1901
Summers, H. E	1902
Fink, Bruce	1903

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FELLOWS.

ALDEN, W. C.	Mount Vernon
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AREY, M. F.	Cedar Falls
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BEGEMAN, L.	Cedar Falls
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NORRIS, H. W.	Grinnell

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NUTTING, C. C. .... Iowa City
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PAMMEL, L. H .... Ames
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ROSS, L. S. .... Des Moines
SAGE, J. R. .... Des Moines
SANDERS, W. E .... Alta
SAVAGE, T. E. .... Des Moines
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KINNEY, C. N .... Des Moines

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LEWIS, W. H. .... Winterset
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WATKINS, H. R. .... Ames
WILLIAMS, I. A. .... Ames

CORRESPONDING MEMBERS.

ARTHUR, J. C. .... Purdue University, Lafayette, Ind.
BAIN, H. F. .... U. S. Geological Survey, Washington, D. C.
BALL, C. R. .... Department of Agriculture, Washington, D. C.
BALL, E. D. .... State Agricultural College, Logan, Utah
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BEACH, ALICE M. .... University of Illinois, Urbana, Ill.
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CARVER, G. W. .... Tuskegee, Ala.
COBURN, GERTRUDE .... Kansas City, Kan.
CONRAD, A. H. .... 18 Abbott Court, Chicago, Ill.
CRAIG, JOHN .... Cornell University, Ithaca, N. Y.
DREW, GILMAN C. .... Orono, Maine
ECKLES, C. W. .... University of Missouri, Columbia, Mo.
FAUROT, F. W. .... Missouri Botanical Garden, St. Louis, Mo.
FRANKLIN, W. S. .... Lehigh University, South Bethlehem, Pa.
FRYE, T. C. .... State University, Seattle, Wash.
GILLETTE, C. P. .... Agricultural College, Ft. Collins, Colo.
GOSSARD, H. A. .... Lake City, Fla.
HALSTED, B. D. .... New Brunswick, N. J.
HANSEN, N. E. .... Brookings, S. Dak.

HANSEN, MRS. N. E.................................Brookings, S. Dak.
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HITCHCOCK, A. S..........Department of Agriculture, Washington, D. C.
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MALLY, F. W............... ....Hulen, Tex.
MALLY, C. W....................Grahamtown, Cape Colony, South Africa
McGEE, W. J....................Bureau of Ethnology, Washington, D. C.
MEEK, S. E................. ......Field Columbian Museum, Chicago, Ill.
MILLER, B. L............... ....Bryn Mawr, Pa.
MILLS, S. J.... ....Denver, Colo.
NEWELL, WILMON........... ....Capitol Building, Atlanta, Ga.
Osburn, Herbert...... ....State University, Columbus, Ohio
Owens, Eliza.... ....Bozeman, Mont.
PATRICK. G. E..... ......Department of Agriculture, Washington, D. C.
PRICE, H. C.............. ....State Uniyersity, Columbus, Ohio
READ, C. D............................Weather Bureau, Vicksburg, Miss.
REPP, J. J..................... ....Philadelphia, Pa.
SIRRINE, F. A...................124 South Ave., Riverhead, New York
SIRRINE, EMMA..Dysart, Iowa
SPENCER, A. C............. U. S. Geological Survey, Washington, D. C.
STULL, W. N........... ....Mallinkrodt Chemical Co., St. Louis, Mo.
TODD, J. E. ....
TRELEASE, WILLIAM...... ....Missouri Botanical Gardens, St. Louis, Mo.
UDDEN, J. A...Rock Island, Ill.
WINSLOW, ARTHUR................... ....Kansas City, Mo.
YOUTZ, L. A........................ ....New York City, N. Y.

Ferdinand Reppert.

BY B. SHIMEK.

The summer of 1903 witnessed the close of the life of one of the most ardent lovers of Nature within the borders of our State. To write a truly appreciative sketch of a life like that of Ferdinand Reppert is no easy task. The ordinary chronological details of his life could not be obtained by the writer of this sketch, nor could he secure a photograph in order that the kindly features of the deceased naturalist might look from these pages upon the friends who mourn his loss. He was a native of Cape Girardeau, Missouri, a graduate of the Michigan College of Pharmacy, Ann Arbor, and since the early 70's a practicing pharmacist in Muscatine, Iowa. But long after these details, even now obscure, will have been forgotten, he will be remembered for his splendid work in his chosen field of botany, for his quiet but intense enthusiasm, and for the scientific accuracy and thorough honesty of his work. He was essentially a lover of out-of-doors. The laboratory and library invited him only as they threw additional light on the activities and habits of his beloved plants. Those who, like the writer, had the pleasure of accompanying him in his studies in the field, were deeply impressed with the keenness of his observations, the accuracy of his judgment, and the truly scientific spirit which he displayed in his work, and all have regretted that it was not possible for him to concentrate all his energies upon his favorite subject. As it was, his labors were not unproductive of results. He was for a number of years a member of this Academy, and was well known to botanists far beyond the limits of the State. He was joint author of the "Flora of Scott and Muscatine Counties," the account of the Muscatine flora being almost wholly his contribution. This paper was published in 1900, but he was then already well known to professional botanists as a keen observer, and the discoverer of many rare and unique Iowa plants. He also left a fine collection of plants, largely Iowan, which is now in the herbarium of the State University, and which is a splendid monument to his industry and scientific acumen. The collection also includes the results of two expeditions to the west, the more productive of which extended over more than 600 miles of the Rockies in Colorado and Wyoming, and was made in 1898, in company with his old-time friend and co-laborer, Prof. F. M. Witter. These fruits of his labors will long continue to be of assistance to students of botany, while the memory of his kindly, appreciative nature, and of his gentle personality, will always remain with those who knew him best.

PROCEEDINGS

OF THE

EIGHTEENTH ANNUAL SESSION

OF THE

IOWA ACADEMY OF SCIENCES.

The eighteenth annual session of the Iowa Academy of Sciences was held in the physics lecture room of the State University of Iowa at Iowa City, April 14 and 15, 1904. In the business session the following matters of general interest were passed upon:

REPORT OF THE SECRETARY.

TO THE MEMBERS OF THE IOWA ACADEMY OF SCIENCES:

During the past year three additions were made to the list of fellows. Three fellows, Messrs. Eckles, Stull and Wilder, having removed from the state, were transferred to the corresponding membership list. For failure to pay membership dues five fellows were dropped from the list. The number of associate members was increased by the addition of seven new names. Seventeen associate members withdrew or were dropped from membership for non-payment of dues. The revised roster shows sixty-three fellows, forty-four associate members and fifty-two corresponding members, making a total membership of one hundred and fifty-nine. Five fellows, Messrs. Frye, Keyes, Leonard, Price and Repp, having removed from the state, should be transferred to the list of corresponding members. The secretary has not been informed of any loss by death in the membership of the Academy during the past year.

It is evident that there should be a determined effort made to increase the membership of the Academy. In a state as large and prosperous as ours,

with so many educational institutions in which scientific work of a high grade is carried on, there must be a large number of scientists and those interested in pure science who ought to be, but are not yet members of the Academy.

The Secretary of the Academy, Mr. A. G. Leonard, on removing from the state last September, after conferring with officers of the Academy asked the undersigned to act as secretary in the interim. At a special meeting of the Academy held in Des Moines, December 7, 1903, this relation was continued.

Two important factors in the secretaryship of an Academy of Sciences need emphasizing; first, permanency; second, accessible location of the secretary. Since the Iowa Academy of Sciences lost from its active membership Prof. Herbert Osborn the secretaryship and with it the permanent progressive policy of the Academy have lost much of their desired stability. This lack of permanency has been in part offset by the fact that the secretary during this time has usually resided in or near Des Moines. By the articles of incorporation of the Academy its principal place of business is in Des Moines. The printing of the proceedings must be done in the same city. The exchanges of the Academy deposited in the State Library need some sort of supervision.

As usual of late years, the tenth annual volume of the proceedings was delayed by the printers and was not ready for distribution until September, 1903. Aside from the illustrations there were but 178 pages in the volume, a marked decrease in number from that of the ninth volume.

The old grievance of exorbitant charges for reprints still exists. So unreasonably high were the prices fixed that it seemed best not to attempt to supply them last year. There seems little hope of getting better terms from the printer. And yet if we expect papers of a high grade of excellence to be presented at our annual meetings we must assure the members of the Academy that reprints will be furnished. This matter is one of vital importance to the welfare of the Academy and should receive our most careful attention. To pay the prices asked by the printer is entirely out of the question. Even with the goodly surplus at present on hand in the treasury it would be impossible.

Respectfully submitted,
H. W. NORRIS, Secretary.

REPORT OF TREASURER FOR 1903-1904.

RECEIPTS.

Balance from 1902	$ 46.20	
Back dues	50.00	
Annual dues, seventeenth meeting	67.00	
Initiations and transfers to fellows	38.00	
Annual dues, eighteenth meeting	1.00	
Sale of Academy Proceedings Part 1, Volume 1	3.00	
Sale of Proceedings other than Part 1	2.25	
Total		$ 207.45

DISBURSEMENTS.

Expense of lecture, stereopticon express paid Professor Calvin	$ 15.00	
Printing programs, seventeenth meeting	6.00	
Printing tickets and envelopes	3.25	
Printing 1,000 letter-heads	3.50	
Printing notices sent out, programs eighteenth meeting, etc	10.25	
Expense, B. Shimek, treasurer, drayage for lantern, postage and stationery	3.40	
Binding of seventeenth annual Proceedings for members	33.00	
Expense of tying up seventeenth annual Proceedings	5.00	
Expense, postage, B. Fink	2.76	
Expense, postage, express, drafts, H. W. Norris, treasurer	3.61	
To Herbert Osborn for sale of Proceedings, Part 1	3.00	
Cash on hand	113.68	
Total		$ 207.45

At a special business meeting on December 7, 1903, held in Des Moines, Iowa, the following members were elected.

FELLOW.

A. W. Martin.

ASSOCIATE MEMBERS.

E. A. Jensen, C. Ellis, H. S. Faucett, H. Frandsen, and H. R. Watkins.

At the meeting held in Iowa City, December 14 and 15, 1904, the following were added to our membership:

FELLOWS.

L. W. Anderson, Iowa City; R. E. Buchanan, Ames; J. E. Guthrie, Ames; John J. Lambert, Iowa City; C. F. Lorenz, Iowa City; J. H. Paarman, Davenport.

ASSOCIATE MEMBERS.

R. M. Anderson, Iowa City; W. M. Barr, Grinnell; George Beane, Fayette; W. B. Bell, Iowa City; (Miss) M. L. Boswell, St. Katharine's, Davenport; C. H. Edmundson, Iowa City; Esther Jaquith, Grinnell; Edna King, Ames; C. N. Kinney, Des Moines; Charles J. Lambert, Iowa City; John M. Lindley, Winfield, Iowa; O. D. Longstreth, Iowa City; J. W. Meek, Oskaloosa; Lulu Miles, Lineville; Katy Miller, Grinnell; Dr. Moorehead, Ida Grove; Edwin Morrison, Oskaloosa; A. B. Storms, Ames; A. O. Thomas, Iowa City.

F. A. Wilder was transferred from the list of corresponding members to active membership as fellow.

CORRESPONDING MEMBERS.

T. C. Frye, C. R. Keyes, A. G. Leonard, J. J. Repp, and H. C. Price were transferred to the list of corresponding members.

The following officers were elected for the ensuing year:

President—B. Shimek.
First Vice-President—L. H. Pammel.
Second Vice-President—M. F. Arey.
Secretary—T. E. Savage.
Treasurer—H. W. Norris.
Elective members of the Executive Committee—H. E. Summers; C. N. Kinney; G. E. Finch.

DISTRIBUTION OF REPORTS.

The committee on distribution of the proceedings reported as follows, and the report was adopted:

Where several hundred copies of the respective volumes are on hand the committee suggests that copies of the respective volumes, with the exception of volume I, be sold to members of the Academy to complete their sets as near as possible, and to science teachers in the high schools of our state, at the rate of 25 cents per copy, until the number of copies of these volumes is reduced to 200. This number of copies of each volume shall be kept as a reserve supply for which the price of 50 cents per copy is to be charged.

Respectfully submitted,

T. E. SAVAGE,
H. E. SUMMERS,
M. F. AREY,
Committee.

REPRINTS.

The committee on secretary's report submitted the following with regard to reprints:

That the secretary be instructed to see that the printer arranges the matter of the annual proceedings in such form that each paper shall constitute a distinct article by itself, it being the understanding that papers printed in such fashion may be separated and each author may have his own reprints. Adopted. Voted that the question as to where reprints in excess of 100 shall come from be referred to the executive committee.

The committee on pure food legislation reported progress and asked to be continued. Voted that the committee be continued and instructed to report in the proceedings.

REPORT OF COMMITTEE ON PURE FOOD LEGISLATION.

During the past year a committee of pure food legislation has co-operated with a committee from the State Department of Agriculture, in investigating food products sold in Iowa. As a result of the investigations, the following results are of interest:

The various products which were selected for investigation were grouped as follows—

Group I.

1. Cream of tartar and baking powders.
2. Mustard.
3. Pepper, allspice and other spices.
4. Vinegar.

Group II.

5. Honey.
6. Molasses and other syrups.
7. Candy.
8. Maple sugar and syrup.
9. Jellies and jams.
10. Lemon and vanilla extracts.
11. Fruit syrups.

Group III.

12. Lard.
13. Linseed oil.
14. Buckwheat flour.
15. Catsups.
16. Coffee and substitutes.
17. Tea and substitutes.

Group IV.

18. Impure ice.
19. Coloring matters used in canned goods.

The amount of money which could be used for the investigation was limited and it was decided to carry on the work as far as the funds would allow.

The first group of products selected were the vinegars. Twelve samples were analyzed with the results as shown in the table which formed a part of the report. From the chemical analyses, it was shown that eight of the twelve samples were not cider vinegar, or, in other words, 66⅔ per cent of the products sold as cider vinegar are not produced from cider.

In this connection, it is of interest to note that in Massachusetts during the year ending September 20, 1902, out of 270 samples of vinegar, 178 were condemned as not meeting the requirements of the state law. In Ohio, twenty-four samples of a total of seventy were regarded as adulterated. Many of the samples were below the strength required by law. The retail dealers have no means of determining whether a vinegar is pure or not. They have simply the word of the jobber. I have in mind, a case, where the vinegar sold by a merchant as cider vinegar, on examination proved to be a spirit vinegar. He reported the fact to the dealers in Chicago, and it was claimed by them that they purchased the product for cider vinegar, and were themselves misled by the statement of the makers. Some of the dealers claim that the price is an indication whether the product is pure cider vinegar or not. There is no doubt that the vinegars sold to the public are grossly misrepresented.

JELLIES, PRESERVES, AND SYRUPS.

Twenty-nine samples of these products were examined, as shown by the results of the chemical analyses. In twelve of the samples glucose was found to exceed 50 per cent of the product, and in seventeen an amount exceeding 25 per cent of the product was present. In many of the other samples the amount of cane sugar present was very small.

In the report of the Food Commissioner of Ohio, for 1902, nineteen samples of syrups were analyzed and eight were adulterated. The report for August, 1902, of the Dairy and Food Commissioner for Michigan, shows that two samples of molasses and seventeen samples of jellies were analyzed and all were found to be adulterated.

Many of these substances are labeled so as to indicate that they are a compound product. Most of them are artificially colored in order to make the imitation complete. It is of interest also to note that on many of the labels there is printed something like the following, which is taken as an example: "Compound, 50 per cent simple syrup, 50 per cent corn syrup, colored and flavored." Another example is: "Syrup compound, 50 per cent corn syrup, 20 per cent sugar syrup."

On one jar of jelly, in very small letters, is printed: "60 per cent apple juice, 35 per cent corn syrup, 5 per cent sugar; artificially colored." This product was labeled current jelly. Another label stated that the compound was 50 per cent fruit, 25 per cent corn syrup, 20 per cent sugar, and 5 per cent spices and flavors. Many of these products were prepared in other states and these statements were printed on the label in order to satisfy the demand of pure food laws of many of the states. The results of the analyses of the various products called jams, jellies, and syrups show that glucose is present in a number of the samples and in large amounts.

MUSTARDS.

In the analysis of mustards, our work, owing to the limited funds at our disposal, was only of a qualitative nature. Many of the samples gave heavy indications for starch, which is the common substance used in the adulteration of mustard, and may be present to the extent of 50 per cent of the products.

BAKING POWDERS.

In baking powders, it was found that alum was present in three of the samples sent for examination; and in the cream of tartars, of the four samples examined, only two were found to be pure.

CATSUPS.

In catsups it was found that they were preserved by a salt of benzoic acid and artificially colored.

In connection with the adulteration of catsups, the following extract, taken from the report upon Food and Drug Inspection, of Massachusetts, for 1902, may be of interest:

"As an example of the character of material used in many of the cheaper preparations of tomato catsups, the following quotations may be of interest as they are taken from the circular of a commission merchant outside the

state, the circular being headed in large letters, 'Tomato Pulp for Sale,' and advertising some twelve different grades for use in making catsups."

"One hundred barrels of old goods, made partly from whole stock and partly waste, boiled down nearly to catsup thickness, has preservalin in it, fine goods, but some of it is fermented; packed in good oak whisky and wine barrels. Price $2 per barrel."

"Two hundred and twenty-five barrels new goods made from waste, has benzoate of soda in it; packed in good whisky and wine barrels, at $3 per barrel, net cash."

"Three hundred barrels old goods, partly whole stock, partly waste, has salicylic acid in it; nice goods, but some of it is fermented. Price $2 per barrel."

"Four hundred barrels new goods, Jersey style, good red color. Price $3 per barrel."

With prices as low as the above quotations indicate, it is difficult to see how a cheaper basis for catsup than real tomato stock could be supplied, so that pumpkin pulp and other materials alleged to be used for such preparations could not be furnished at a much lower price.

CREAM OF TARTAR.

Cream of tartar is used extensively in the household, largely in connection with bread making. This substance is in many cases adulterated to a large extent. Starch, calcium phosphate, and calcium sulphate (Gypsum) being used for this purpose. For an illustration the following analyses will show to what extent this substance has been adulterated.

Alum	62.27	
Silica	1.00	
Lime	.76	
Starch	14.39	
Cream of tartar	21.58	
Total		100.00

Or this:

Cream of tartar	None.	
Acid calcium phosphate	25.30	
Calcium sulphate	24.10	
Starch	10.60	
Moisture	40.00	
Total		100.00

The above results are taken from a report of the Ohio Food Commissioner of a few years ago. The last report of the same state shows that of the twenty-seven samples collected none were found to be adulterated. This was not so, however, in the past years, as it was very common to have samples adulterated to the extent given above.

In Massachusetts, 326 samples were collected in 1902, and twenty were found to be adulterated. Four samples were tested in connection with this investigation and two gave indications of adulterations.

LEMON AND VANILLA EXTRACTS.

The funds for the investigation would not allow the work upon extracts to be undertaken. The following results taken from the reports of other states will be of interest. In Massachusetts, during the year ending September 30, 1902, sixteen samples of lemon extract were examined and thirteen did not meet the standard required by the state law. The investigation for the vanilla extracts gave the following results:

"Fifteen out of eighteen samples examined were found adulterated either by reason of being artificial tinctures of vanilla and not true extracts of the vanilla bean, or because they failed to conform to the formula in cases where there is one. The use of the formula for this class of goods is on the increase, but in many cases they are not found to conform to the results of our analyses."

In Ohio during the past year sixty-eight samples were collected and sixteen were found to be adulterated.

In Michigan, six samples of vanilla extract were collected in August, 1903, and all were found to be adulterated. The extract of vanilla appears to be adulterated more than lemon extract, artificial vanilla and coumarin being the products used, with artificial coloring.

SPICES.

The spices used in the household are no doubt adulterated to a greater extent than any of the products used for food.

Pepper is adulterated with ground pepper shells, ground olive pits, corn meal and roasted cocoanut shells.

Allspice is adulterated with wheat and exhausted ginger.

Cassia is adulterated with exhausted ginger and cassia buds.

Cayenne is adulterated with cornstarch and turmeric.

Cloves are adulterated with allspice, nut shells, and sand and sweepings.

Ginger is adulterated with turmeric, buckwheat and powdered charcoal.

Mace is adulterated with cornstarch and wild mace.

From the above results it will be seen that the people of Iowa are subjected to a large amount of fraud in connection with their food products. The bill to prevent food adulteration was presented to the last legislature, but failed. There is great need, on the part of those interested in the welfare of the state, to exert their influence for the passing of a pure food law. It is certainly not to the honor of our state that we stand among the group of two or three states which have not upon their statute books a pure food law, for preventing imposition upon the innocent and unsuspecting purchaser of food products.

Respectfully submitted,

J. B. WEEMS,

Chairman of Committee on Pure Food Legislation.

At the literary sessions the following papers were presented:

The Presidential address, "Two Centuries of North American Lichenology."—Bruce Fink.

"The Animal Cell in the Light of Recent Work."—Gilbert L. Houser.

"The Action of Chloric Acid on Metals."—W. S. Hendrixson.

"The Importance of Vital Statistics in the Study of Social Science."—Gershom H. Hill.

"A Buried Peat Bed and Associated Deposits in Dodge Township, Union County."—T. E. Savage.

"Some Notes on Iowa Flora."—L. H. Pammel. (Illustrated with lantern slides.)

"Some Features in the Analysis of Dolomite Rock."—Nicholas Knight.

"The Softening of Hard Water."—Nicholas Knight.

"Some Bacteriological Examinations of Iowa Waters."—L. H. Pammel, Edna King, R. E. Buchanan. (Illustrated with lantern slides)

"The Determination of Chlorides by Means of Silver Chromate."—Launcelot W. Andrews.

"A Chemical Study of Rhus glabra."—Arthur W. Martin.

"The 'Furcula' in the Collembola."—J. E. Guthrie.

"The Sioux City Water Supply."—Alfred N. Cook.

"A New Deposit of Fuller's Earth."—Alfred N. Cook.

"The Flora of Emmet County, Iowa.—R. I. Cratty.

"Action of Sodium Thiosulphate on Silver Salts."—W. M. Barr. (Introduced by W. S. Hendrixson.)

"Regeneration in the Crayfish."—John J. Lambert. (Introduced by Gilbert L. Houser.)

"Stereoscopic Projection in Natural Colors."—C. F. Lorenz. (Introduced by A. A. Veblen.)

"Notes on the Position of Nileus vigilans in Strata at Elgin, Iowa."—G. E. Finch.

"A Contribution to our Knowledge of the Development of Prunus Americana."—R. E. Buchanan.

"Additions to the Iowa Flora."—B. Shimek.

"The So-called Dorsotrachealis Branch of the Seventh Cranial Nerve in Amphiuma."—H. W. Norris.

"The Vagus and Anterior Spinal Nerves in Amphiuma."—H. W. Norris.

"The Lichen Flora of the 'Ledges,' Boone County, Iowa."—Katy A. Miller. (Introduced by Bruce Fink.)

"A Method of Determining Chloric Acid."—W. S. Hendrixson.

"Periodical Literature in Iowa on the Subject of Chemistry."—W. S. Hendrixson.

"A Geological Situation in the Lava Flow, with Reference to the Vegetation."—Harriet M. Clearman.

"A Synthesis of Ethyl Alcohol from Acetylene."—John C. Frazee. (Introduced by C. O. Bates.)

"New Method of Cohesion of Water and Adhesion of Mercury Apparatus."—Edwin Morrison. (Introduced by H. W. Norris.)

"A Preliminary List of the Flowering Plants of Madison County."—H. A. Mueller.

"Remarkable Occurrence of Aurichalcite."—Charles R. Keyes.

"Certain Basin Features of the High Plateau Region of Southwestern United States."—Charles R. Keyes.

"Note on the Carboniferous Faunas of Mississippi Valley in the Rocky Mountain Region."—Charles R. Keyes.

"A Convenient Voltaic Cell."—L. Begeman.

PLATE I.

EDWARD TUCKERMAN, 1817–1886.

PRESIDENTIAL ADDRESS.

TWO CENTURIES OF NORTH AMERICAN LICHENOLOGY.

BY BRUCE FINK.

PRELIMINARY STATEMENT.

Surely no apology is in order for offering here an address in which attention is directed for the short time to a limited field in one of the biological sciences. All men of science are interested to some extent in the history of the rise and progress of every phase of scientific inquiry, and even for the layman who may favor us with his presence this evening, it is hoped that the record of devotion, sacrifice and completion of valuable work will afford something of interest.

The history of American lichenology, so far as we have been able to trace its tangible origin, begins with the year 1703, when appeared the first list of American lichens. However, lichenology in America is not a thing apart, but its beginning and much of its development are closely related to the work in Europe, begun considerably earlier and always in advance of our own. Lichens have for at least two centuries excited more than passing interest in our own country, but we are yet too young a nation to have produced a large number of workers especially interested in a class of plants, comparatively inconspicuous, and having little economic value of such a nature that one may find a livelihood in their study. So it happens that lichens frequently receive some attention as objects of nature study both for children and adults, and are studied

by some ambitious young botanist long enough to complete a list of the commoner species of his locality or State; but as a rule the botanist, true to the American instinct, soon turns his attention to some lucrative employment of his botanical training. In spite of all this, the record of the work accomplished is creditable, and even in recent years in which the trend of botanical activity has been rather away from taxonomic studies, American lichenists have, by turning in part toward morphological, physiological and ecological studies, and by persistence in taxonomic labors as well, produced a good amount of valuable work. While some of the results obtained in Europe in the last two decades are the best, whether of the taxonomic, morphological or physiological study of lichens.

EUROPEAN LICHENOLOGY AND ITS INFLUENCE ON AMERICAN.

So intimate is the relationship between American and European lichenology that a brief review of the latter is necessary in order to understand the former. While very little has been written regarding the history of American lichenology, the array of papers treating European lichenology, from the historical standpoint is too formidable for consideration here. However, Kremplehuber, in his "Geschichte und Litteratur der Lichenologie", in three volumes dealing with the lichenology of all lands from the beginning till 1870 in a most comprehensive manner, gives the facts from which we may draw for our view of European lichenology, and from which we may also gain valuable knowledge regarding American lichenology. Krempelhuber seems to make nearly all of his periods begin with years in which appeared some remarkable work in lichenology. As to the first period, his dates are somewhat uncertain and confusing, but he makes it begin with the earliest times and doubtless intends that it shall extend to 1694, the year in which appeared Tournefort's "Elemens de Botanique", in which for the first time the lichens are separated from the mosses, algae and fungi. His second period, as best we can make out from his dates, extends

from 1695 to 1728, or from Tournefort to Micheli. The third period covers the time from 1729, in which appeared Micheli's "Nova Plantarum Genera juxta Tournefortii Methodum Disposita", in which attention is called for the first time to the impropriety of grouping all lichens under the single genus, *Lichen*, to 1779, or to Weber, whose name also seems to appear as Wigger. Period four reaches from 1780, in which year Weber in his "Primitiae Florae Holsatiae" (the author's name appearing as Wigger) successfully departed from the old custom of classifying lichens entirely according to the general form and structure of the thallus and considered also the apothecia, to 1802, or to Acharius. The fifth of Kremplehuber's periods extends from 1803, in which year Acharius, in his "Methodus Lichenum", for the first time gave somewhat adequate descriptions of all known lichens, to 1845 or to DeNotaris. Krempelhuber's sixth and last period extends from 1846, when appeared De Notaris' "Frammenti Lichenographici", in which for the first time some prominence is given to spore characters in the classification of lichens, to 1870, in which year Krempelhuber completed his history in the third volume of his "Geschichte." Schneider in his recent "Textbook of Lichenology", presents a somewhat different division into periods, which is as a whole scarcely an improvement upon Krempelhuber's method of division. However, we may well agree with Schneider that the announcement by Schwendener of his belief in the dual nature of lichens in 1868 may be regarded as the beginning of a new period, the importance of this announcement hardly appearing before Krempelhuber had completed his work. Schneider also recognizes another period beginning with the year 1894, when appeared Reinke's "Die Stellung der Flechten in Pflanzensystem", in which the author put forth his views regarding the autonomous nature of lichens and the consequent propriety of still regarding them as a distinct class of plants. This is by no means Reinke's only contribution to lichenology, and no one who has seen his papers can doubt their great value. However, there is as yet no great evidence that his peculiar views as to the autonomy

of lichens will ever be generally accepted, and the present writer is disposed to regard the establishment of a period dating from 1894 as at least premature.

Regarding the early studies in the old world, Theophrastus, in the third century before Christ, seems to have named a number of lichens, giving very crude descriptions. *Usneas* and other conspicuous forms, including *Roccella tinctoria*, on account of its coloring properties, seem to have been the lichens thus early described. A few observers also studied lichens somewhat during the first century of the Christian era; but the dark ages soon intervened, and for several centuries, lichenology was, like other sciences, wholly neglected. With the revival of the sixteenth and seventeenth centuries, a few of the more conspicuous lichens were again described. As already stated, it was not till 1694 that lichens were for the first time recognized as a distinct group of plants, and at this time less than a hundred species were known. Such was the condition of the science of lichenology when the first work was done in America.

The men who did this early work were not specialists in lichenology, for specialists in so limited a sense were hardly known at this time. But toward the close of the eighteenth century, there appeared a number of botanists who began to study the lichens somewhat seriously. Though careful study of the old literature has given me but 221 pre-Linnean (1753) lichens, Acharius, the first great lichenist, in his "Methodus Lichenum," just a half century later (1803) described approximately 500 lichens then known. Such were the conditions at the beginning of the second century of American lichenology, and it may be added that the prevailing ideas regarding the apothecia, the soredia, the so-called spermagonia, the spermatia and the spores were crude and in general erroneous. It is true that Acharius studied the spores as well as he could with the crude magnifiers of his day, and figured many apothecia, but even in his "Lichenographia Universalis" of 1810, his attempts at figures of spores are few and very unsatisfactory.

Early in the nineteenth century, monographs of genera began to appear in Europe, and after the first quarter of the century, European lichenists of note became so numerous that we can mention only a few of them in passing. Wallroth, Körber, Massalonge and Nylander, each in turn did much for systematic lichenology in Europe during the century just closed and helped directly or indirectly in our studies as well, while perhaps Elias Fries, through his influence upon Tuckerman, impressed himself upon American lichenology more than any one of them. Arnold, Stizenberger and Müller also aided greatly in the closing years of the last century, and Wainie, Zahlbruckner and Hedlund are among the Europeans who have, in the present century, aided effectually in our work.

Wallroth did good work for his day in the morphology and physiology of lichens, and other European workers in these fields have profoundly influenced our American thought and must be mentioned. About the middle of the last century appeared works by DeBary and Schwendener, which were the beginning of a revolution in ideas regarding the nature of lichens. De Bary detected the close relationship between the lichens and the algae on one side and the fungi on the other, and Schwendener, at first hostile to the views of De Bary, in 1868 announced his belief that the so-called gonidia and gonimia were really algae growing under peculiar conditions. He set to work to study the algal types occurring in lichen thalli, and received credit for establishing the now generally accepted view as to the dual nature of lichens. The fungal portion of the lichen commonly gives form to the plant, or colony, and produces the spores, and American as well as European writers of text-books soon began to follow De Bary and Schwendener, placing the lichens among the fungi. The older systematic lichenists of two continents were almost violently hostile to the new theory, and many of the younger and better trained lichenists and botanists, who accept the newer views as well established, have not felt so certain that the distribution of lichens among fungi is at all a final disposition. Finally, Reinke, in a paper already mentioned, and

published a decade since, has, with some show of good reasoning founded upon recent experiments, attempted to introduce into the scientific world the idea that the relation between the algae and the fungus or the fungi of the lichen colony is so close that we have not a colony but an autonomy. Enough was stated on a previous page regarding the views of Reinke, and it need only be reiterated that, though not yet generally accepted, they are not to be passed over lightly, nor need botanists suppose that the question as to the classification of lichens is at all settled, much as such a consummation is to be desired. But leaving this matter, Bonnier, Fünfstuck, Jumelle, Lindau and Zukal must all be mentioned as men whose works will influence American lichenology increasingly as we turn our attention more and more toward morphological and physiological studies. Nor may we leave the consideration of the impress of European upon American lichenology without reference to the name of Stahl, whose work is well known to American botanists.

INTRODUCTORY VIEW OF AMERICAN LICHENOLOGY.

It must be apparent enough that in discussing American lichenology, it would not be at all satisfactory to follow the outline of periods adopted in a study of general lichenology, and we shall introduce here a division into periods, which will at least serve our purpose. Acharius in his "Lichenographia Universalis", 1810, for the first time definitely mentions a considerable number of American lichens in a work of first importance, and we may fittingly regard the work done before 1810 as belonging to *The Period of Beginnings.* During this period and following it the impress of Europe was even more plainly noticeable in American lichenological studies than it has been in more recent times. In 1847 was read Tuckerman's "Synopsis of the Lichens of the United States and British America" (published the following year), and in the same year Tuckerman also began to issue his exsiccati under the name, "Lichenes Americae Septentrionalis Exsiccati".

These being the first really important works by an American, it will be seen that from 1810 to 1847 we were emerging somewhat from the influence of Europe, and the time included between these two dates we may appropriately regard as *The Euro-American Period* of American lichenology. In 1888, two years after the death of the author, appeared the second volume of Tuckerman's "Synopsis", which closed the work of this great Lichenist. From 1847 to 1888 the influence of the one man, Tuckerman, was plainly to be seen upon nearly all of the work done in American Lichenology, and we may consider this time as *The Tuckermanian Period.* It is not to the discredit of Tuckerman that we are pleased to record that since his death there has been a gradual breaking away from ideas held by him and his co-workers as to the nature and proper classification of lichens, and since we are in want of a better name, we may call the time subsequent to 1888 *The Recent Period* of American lichenology. The change going on is perhaps most plainly outlined in Schneider's "Text-Book" and in his more elementary "Guide", but it is apparent also in some papers published in the present decade, and a considerable amount of material still in manuscript will, it is hoped, bring needed changes in synonomy, description of the species and classification.

THE PERIOD OF BEGINNINGS (FROM THE BEGINNING TO 1810.)

If we compare the outline of American lichenology suggested above with that previously given for Europe, it appears that the date, 1810, taken as the close of our first period, is only eight years later than that which closes the fourth of Krempelhuber's periods. Comparing a little further, we find that the date of the first definite and certain mention of a North American lichen, 1703, is just nine years after the close of the first of Krempelhuber's periods. Thus it seems that the work on lichens began in our land as soon as these plants were recognized as distinct from mosses, algae and fungi, and at a time when only about 75 lichens were known—possibly 100. Botanical work

had been done before this time in America, for as early as 1643 a course of one hour a week in Botany was established at Harvard. This was more than a century before the first American professor of Botany, Adam Kalm, was, about 1768, installed at the University of Pennsylvania. The first serious collecting of plants in our country seems to have been done by Thomas Walker in South Carolina, in 1740, and following him Kalm collected and sent to his teacher, Linneus. Michaux, in 1780, began his famous trip through the South and West to the Mississippi river, culminating in his flora of North America with 1700 plants, and Pursh, Nuttall, Houston and Clayton followed shortly and aided in the early work. Of these men, Michaux and Walter at least collected some lichens. However, American lichenology can be traced back nearly a half century before any of this collecting was done, to a time when our botanical science in general was in a rudimentary condition. Possibly some of the semi-civilized peoples of North America may have known some lichens as long ago as the days when Theophrastus and later the elder Pliny seem to have known something of them, and when the Greeks supposed plants to possess mind and soul and to be capable of pleasure and pain. Again, some of the early settlers in America may have done some obscure work on lichens and may have carried some specimens to Europe where they were perhaps studied, but the first definite record that I am able to find is that Carolus Plumier, in his work published in 1703 at Paris, records *Sticta damaecornis*. Thus so far as tangible evidence is concerned, North American lichenology appears to be just about two centuries old. This work of Plumier's appeared a half century before Linnaeus had devised the binomial system of plant names, and the plant was designated, *Lichen rufescens, cornua, damae referns*, from resemblance of the thallus lobes to buck horns. It is not so strange that this plant, no doubt picked up by chance, happened to be new to science when we recall that the whole number of lichens known at this time was less than 100. Petiver, in a work published in London, 1712,

mentions this same American lichen and no more. However, it must be stated also that Petiver had, in the second century of his mosses in 1695 (Petervarini Musci Cent.) sent out *Parmelia perforata*, under the descriptive designation, *Lichen arboreus Americanus scutellis magnis donatus;* but I am unable to ascertain whether from North or South America. Also, H. Sloane in his "Catalogus Plantarum Jamaicae," London, 1696, is said to have mentioned seven species of previously known lichens under some sort of classification. This work I have not yet investigated sufficiently to be certain but that we should carry our history back to 1696 at least. But turning to tangible things, our *Sticta damaecornis* is the eighty-sixth known lichen recorded by Kremplehuber, and the title under which the plant appears is the forty-first of his references to lichen literature. Next in order, it is certain that Gronovius in his "Flora Virginica," 1739-1743, listed nine North American species with short diagnoses. Among these were *Evernia lacunosa*, *Parmelia perforata* and seven other very common and conspicuous species. After an interval of four decades, we hear of the study of American lichens again through the work of O. Swartz in the West Indies, 1783-1808. In three editions of his work, he gives lists, descriptions and illustrations of 25 lichens. These are common plants, all recorded in Krempelhuber's "Geschichte," and these pages need not be burdened with the names, though it may be in order to state that all but the last three were placed under the genus, *Lichen*. During these years, H. Muhlenberg, in his "Index Flora Lancastriensis," 1793, gives a list of 27 species with no authorities and all under the genus, *Lichen*. Also in 1803, Michaux, in his "Flora Boreli-Americana," noticed 21 species of North America, of which 7 new ones may be found listed in Krempelhuber's "Geschichte." Likewise, in 1803 appeared Acharius' "Methodus," in which are mentioned with descriptions a considerable number of North American lichens, but usually without any statement as to distribution, so that it is impossible to know just which ones the author knew from America.

Thus closes our first period with a record of 12 titles, counting the four by Schwartz not separately mentioned above, "Species Plantarum" which notices a few lichens from North America and Thomas Walter's "Flora Caroliniana," 1788, which gives 5 under the name, *Lichen*. Plainly this is the period of beginnings, and it becomes apparent that we are still considerably behind Europe in licheno-studies at the close of the period when it is stated that at the time there were no less than 190 papers and books recording lichenological work in Europe, and by no means all taxonomic. Of these European titles 54 are pre-Linnean (before 1753). But beginnings there must be, and the books and papers discussed above are interesting and important in that they prepared the way for more extended studies.

THE EURO-AMERICAN PERIOD (1810-1847)

Passing to the second period of North American lichenology, we must mention first the great work of Acharius, "Lichenographia Universalis," in which are described a few more than 100 of our lichens, for the most part collected by Schwartz, Muhlenberger, Michaux and Menzies during the previous period. In this great work by Acharius are described only 786 lichens, so that figures prove that our known lichen flora of the time amounted to somewhat more than one-eighth of the total for the world. "Lichenographia Universalis" appeared in 1810 and "Methodus Lichenum" by the same author in 1814. This second work is also valuable for American lichenists, and it may be said that the two works by this early European lichenist made possible, or at least led to, the appearance of some distinctly American works, dealing in part or wholly with our lichen flora. Of these the first is Muhlenberg's "Catalogue of Plants of North America," published at Philadelphia in 1818 and containing a list of 184 North American lichens. This is the first considerable list of our lichens published in America, and the number is large for the time. In passing it is only fair to note, however, that Amos Eaton in his "Manual of Botany of North America,"

the edition of 1817, gave a much shorter list based mostly upon the work of Muhlenberg. In 1819, in "A Catalogue of Plants growing spontaneously within thirty miles of New York," John Terrey also gave a list of 66 lichens. This is simply a record of species already known, but the list is the first considerable local one for a small North American area. A. Halsey, in 1823, in his "Synoptic View of the Lichens Growing in the Vicinity of the City of New York," gave a list of 176 lichens with short diagnoses. This is the first work devoted wholly to North American lichens and published in this country, and it gives nine new species, named by Schweinitz. Halsey's 176 lichens for the single locality appears noteworthy when we state that the whole number of lichens known in the State of New York at the present time is 241. Though Pennsylvania and New York are entitled to early pre-eminence in lichen studies, New England comes to the front toward the close of the period and more especially in the next period. So far as we are able to ascertain, besides Tuckerman's beginnings to be considered later, a single catalogue of the present period gives any notice to New England lichens. This is "A Catalogue of Animals and Plants of Massachusetts" by Edward Hitchcock, in which he gives a list of 116 lichens. This catalogue appeared in 1833, and in the following year T. Nuttall, in his "Catalogue of a Collection of Plants made chiefly in the valleys of the Rocky Mountains or Northern Andes" by A. B. Wyeth, lists three lichens. This work is barely worthy of note as the first American paper giving a record of lichens from western North America. Menzies had collected considerably on the Pacific coast before this time, but we find nothing previously published in this country regarding his work. Before passing to a brief notice of the portion of Tuckerman's work belonging to the present period, we need only note further that Olney had listed three lichens in Rhode Island and that Russell, about 1840, noted 18 or 20 in Massachusetts, that from 1822 to 1838 Hooker, Presl, Bachelot, Wickström, Meyer and Ramon had all published more or less regarding our lichen flora, in Europe, and

that C. H. Persoon had in the opening year of the period (1810), in a work published in Europe, given a list of 42 lichens from San Domingo and the North American continent. Finally taking up Tuckerman's beginnings, which belong to this period, we find that he published in five papers (1839-1845) on the lichens of New England, lists aggregating upward of 200 species and varieties. Also in 1845 appeared "An Enumeration of North American Lichenes with a preliminary view to the Structure and General History of these Plants and of the Friesian System," in which are enumerated 238 North American lichens. Of these only three are new, and this indicates that Tuckerman had not yet begun any extensive species-making. A list of 53 species given in T. G. Lea's work on the plants near Cincinnati appeared in 1846, this completing our survey of Tuckerman's works of the period.

Thus the period begins with a few more than 100 known North American lichens and closes with scarcely 250. With the exception of the few species known from the western coast and mountains, the work was mostly confined to the New England states, New York, Pennsylvania and Ohio. American papers appear as already noted, and some of them would appear quite noteworthy even at the present time. The whole number of titles for the period is 39, and it is not thought necessary to name the minor ones.

THE TUCKERMANIAN PERIOD (1847-1888.)

In taking up this period we pass from comparatively small things to what Henry Willey fittingly called "the golden age of American lichenology". During this time, everything in American Lichenology was colored by the views of the one man, Tuckerman. However, in dealing with the period, it seems expedient to consider the work of others first and close with that of the man who stands pre-eminent among American lichenists. Among Europeans who have worked on our lichens during the period, we can give space only to Th. M. Fries and W. Nylander. Fries in his "Lichens Arctio Europae, Grönlandicaeque", pub-

lished in 1860, mentions a considerable number of our lichens with descriptions. In a few minor papers also, Fries touches North American lichens, but Nylander, who at the time of his death was undoubtedly first in his knowledge of lichen species, influenced American lichenology of the period more than any American except Tuckerman, and possibly Henry Willey. Nylander's titles dealing wholly or in part with our lichen flora number no less than two dozen. Of these, eight are manuals or monographs, dealing with the general distribution and taxonomy of lichens as a whole or with certain genera, and belong to the present period. Of the remaining 16 titles, all but three belong to the present period, and the 16 contain descriptions of nearly 200 new North American lichens. This is a rather remarkable contribution for a foreigner, but Nylander was doubtless too much given to species-making; and it is not a little unfortunate that he depended too much upon chemical tests in his determinations, while his diagnoses belong to the older, rather brief and inadequate type. So far as we are able to ascertain, this great lichenist began his work on American lichens with the publication of "Lichenes collecti in Mexico", a Fr. Müller, in 1858, and his interest in our flora never waned till the closing year of his life, his death occurring in 1899. In 1895, on sending Nylander a copy of "The Lichens of Iowa", he says in his reply, "Vous etes dans l'erreur ent disant" "it is generally admitted that a lichen is a dual organism" "Cela n'est qu'une calomnie et n'est nullement serieux". Having begun my work on lichens about the close of the period with which we are now dealing I was surely serious in the statement, and calumny was farthest from my thought. However, doubtless the words quoted express not only Nylander's view, but also that of nearly all of the older systematic lichenists of America and Europe, with some of whom I was beginning to correspond at the time.

Krempelhuber, in his "Geschichte," gives the original names of nearly all American lichens described previous to 1870 and also furnishes a very valuable review of our

literature, previous to that date. Indeed, this work is indispensable to the American lichenist. Likewise, some of the European lichenists placed in the next period did some work in the present.

Among American botanists who have contributed to our knowledge of lichens, may be mentioned first the eminent botanist, W. G. Farlow. Dr. Farlow will not be known as a lichenist especially, but as a student in his laboratory I came to know that with his minute knowledge of algae and fungi is found also an accurate and wide knowledge of our lichens. He has published but few papers on lichens, and those that concern our North American flora appeared during the present period.

Turning to men who will be known more especially as lichenists, we may consider first the work of Henry Willey. After Tuckerman and probably Nylander also, Willey was the largest contributor to American lichenology during the period. So far as I have been able to ascertain, his first paper appeared in 1867, and his titles number no less than 27. Of these the most important are his "Introduction to the Study of Lichens," 1887; his "Synopsis of the Genus Arthonia," 1890; and his "Enumeration of the Lichens of New Bedford," 1892. The last two works were published during the next period, but the work was largely done during the period now under consideration. His work on the New Bedford lichens is surely the most complete survey of a limited area known to American lichenology, the whole number of species and varieties resulting from thirty years of study coming within a few of 500, of which 39 were new when found by Willey. His work on *Arthonia* is the only production by an American in the nature of a monograph of a lichen genus. The work is a compilation of 350 known descriptions of Arthonias, and it scarcely reveals the remarkable knowledge of the genus undoubtedly possessed by the writer. In order to bring out the feelings of Willey regarding the recent ideas as to the nature of lichens, I can not refrain from quoting him somewhat at length as follows: "I take this opportunity to express my regret that the American professors of botany have so

generally accepted the 'Schwendener theory,' * * * and this, too, simply as a dogma, without having acquainted themselves with the arguments against it by the eminent lichenographers of Europe, and by Professor Tuckerman in this country. * * * I should be sorry to think that these professors have joined in the conspiracy of silence toward the opposing arguments of such men as Nylander, Müller, Minks, Krempelhuber, Th. M. Fries, Tuckerman and others." I can not give the whole quotation, but it may be seen in the preface of the "Enumeration of the New Bedford Lichens." Willey does not with Nylander quite charge calumny, but he, no doubt, voices the sentiments of the greater number of lichenists of the period. However, it is not remarkable that a man whose botanical work was almost wholly confined to taxonomic studies of lichens should be slow to grasp the value of the recent morphological and physiological studies, and this failure in no way detracts from the great value of Willey's work on the American lichens. I was fortunate enough to have the benefit of his council to a limited extent a few years ago before increasing age forced him to give up his work, and have also had ample opportunity for inspecting his determinations, which were always most carefully made. Finally, we must not fail to state that to Willey belongs the credit for the completion of the second part of Tuckerman's Synopsis after the death of the author.

Passing over some minor workers, our space must now be devoted to the great American lichenist, Tuckerman. He stands out so pre-eminently as an American lichenist that something of his history is a proper part of the history of American lichenology. Born in 1817, he obtained his bachelor's degree in 1837, and two years later finished the law course at Harvard. In 1841 and 1842 he traveled in Europe and met the great lichenist, Elias Fries, at Upsala. Returning to this country, he accompanied Asa Gray to the White Mountains and began the difficult exploration which has rarely been excelled for completeness. That he began his botanical studies in early life and devoted himself chiefly to lichens from the first appears from the fact

that his first "Enumeration of some Lichenes of New England" was published when he was not more than twenty-two years old, and appears to have been read the year before. Excepting Halsey's work considered in the last period, this was the first work by an American, entirely devoted to lichens. His writings, even from the first, contained careful notes which show that he was possessed of a genuine love of botany and a marked adaptability for the work. Thus his meeting with Fries was not merely an incident of his first European trip, and his visits and excursions with this greatest lichenist of his time must have been a great inspiration in those days when botanists were few in number. Indeed, we can hardly estimate the value of this visit to American lichenology. In 1847, nearly ten years after Tuckerman began his work on lichens, appeared his "Synopsis of the Lichenes of New England, and other Northern States and British America." This work was the first to give descriptions and a classification of our lichens, and though it contained but 295 species with 20 new, it was of great importance as it formed a basis from which others could work. It has already been stated that at the same time Tuckerman began to issue his "Lichenes Americae Septentrionalis Exsiccate", this first issue of American specimens giving authentic plants with which collectors could compare their lichens. With the year 1847, then, our Tuckerman period begins. There is some doubt in the mind of the writer whether it might not be better to place the time back to the year when Tuckerman's first work appeared and make it close with 1886, the year of his death. Yet it appears on the whole that the better plan is to begin with the first appearance of a descriptive classification by Tuckerman and to close the period with the completion of the "Synopsis" which was Tuckerman's great contribution.

Tuckerman was more than a lichenist as his knowledge of the general botany of his day was quite comprehensive, while he was a widely read and scholarly man. His professorship in botany at Amherst began in 1858 and continued till his death, twenty-eight years later. But we

must confine our attention to his work upon the lichens. In this field his activity continued to the time of his death, and collections were determined by him, not only from all portions of the Western Hemisphere, but also from the Eastern Hemisphere and from the islands of the sea. How much labor and self-sacrifice is involved in such a task will be appreciated by those who have attempted a similar one even though upon a smaller scale, in some field of taxonomic study. This work brought Tuckerman a knowledge of lichen species possessed by very few even of the European lichenists, and culminated in his two great contributions to North American lichenology, the "Genera Lichenum" in 1872 and the "Synopsis", the first volume of which appeared in 1882 and the second in 1888. Of these two great works, we may venture a few words. The author was conservative in his view of genera and species and seemed to have followed Fries very largely in his classification of the American lichens. His views as to system of classification and as to generic and specific limitations can scarcely be expected to endure in all particulars. Yet his conservatism was by no means a fault, and has no doubt greatly aided in the study of our lichens. Plainly it was not possible for one man to do so much of the great constructive work in American lichenology and at the same time be given to hair-splitting discriminations as to generic and specific limitations. Tuckerman was to lichenology what Gray was to the study of our seed-plants, and we can not pay too high a tribute to the labors of these two men. Tuckerman's contributions to North American lichenology consist of 48 titles, but the number by no means measures the amount of work involved, for he aided others continually and much of his labor received no public recognition. Conservative as he was, his new species and varieties number some 365, about 250 of these being found on the North American continent, some 60 of the remainder on the island of Cuba, and nearly an equal number from various parts of the world and not to be regarded as North American. Including the Cuban lichens named by Tuckerman, the number of species and varieties described

in the two volumes of the "Synopsis", for North America, is approximately 1050, and this number is no doubt considerably below the whole number of North American lichens known by Tuckerman. Thus within the period, the number has grown from 295 to at least 1050, and following Willey's "Supplement", of 1887, no doubt 1225 or 1250 comes nearer to the number.

Tuckerman was pre-eminently a systematist, but some words are in order regarding his views on some other questions of lichenology. In regard to the theory of Schwendener as to the dual nature of lichens, he was more guarded in his statements than many of the other systematic lichenists of his day. While he readily admitted that there were some arguments in favor of the theory, he seems finally to have adopted the views of Minks, and like Müller and some others of his day thought that he had himself demonstrated the existence of the "microgonidia." This he regarded as establishing a boundary line between lichens and fungi. It is pleasant to note, however, that during the years of sharp debate, Tuckerman was always careful and considerate in his treatment of the question. It is also quite as pleasant a task to record that in a short paper entitled "Can Lichens be Identified by Chemical Tests," Tuckerman remarks that his own observations have led him to believe that such tests are scarcely reliable, a view which I suppose meets the approval of later lichenists generally, since we have reached more definite knowledge regarding the anatomy of these plants.

Excellent memoirs of Tuckerman by Willey, Gray and Farlow give much more of detail than can be incorporated here. Finally a considerable amount of good collecting and making of lists of lichens from limited areas must be passed unnoticed, the whole number of titles for the period amounting to 175.

THE RECENT PERIOD (1888 TO THE PRESENT TIME).

There seems to be a feeling extant that American lichenology has been neglected since the death of Tuckerman; but the facts to be brought out below do not bear out this

view, and no doubt botanists generally will be surprised at the statement that more than half of the known references to literature containing some reference to North American lichens belongs to the present short period of sixteen years. True the older titles are more difficult to find, but doubtless my present bibliography will not be very greatly increased. No recent American worker has accomplished so much as did Tuckerman in his long life; but the number of workers has increased, while the quantity and quality of work done by several of them is surely praiseworthy.

In considering the workers of this period, I shall again take up first the labors of Europeans who have aided, and then the American workers. Among the former may be mentioned first J. Müller, whose work on our lichens began as far back as 1877, whose titles dealing wholly or in part with North American species number no less than 24, and whose North American new species number approximately 125. Of these about 90 were described in the present period and add to our flora as known by Tuckerman. Next to Nylander, Müller is the European who has done most for American lichenology. E. Stizenberger had noticed some of our lichens, beginning as far back as 1861, but so far as I am able to ascertain, his only papers dealing wholly with our lichen flora are two, written in 1895. In 1890 he began examining the collections of H. E. Hasse, of California, and described quite a number of new species which have been published in papers by Hasse. Edward Wainio, of Helsingfors, has considered our *Cladonias* in his exhaustive "Monographia Cladoniarum Universalis" 1887-1898, and American students who would work on the genus must *learn how* to use his volumes. Dr. Wainio has in the last few years examined considerably more than 200 of my specimens of American *Cladonias* and a considerable amount of European material on which I have asked his aid. These specimens of the genus are very valuable, especially when it is stated that in all probability fully one-fourth of all American determinations of *Cladonias* would not endure Dr. Wainio's critical examination. That

the Cladonias are fairly well known is attested by the fact that Wainio found only a single new American form in all of the specimens submitted to him, including the most difficult. It will be interesting to note that Wainio regards the western hemisphere the richest field in *Cladonias.* The eminent botanist and lichenist, A. Zahlbruckner, of Vienna, has recently published two papers in which he describes 32 new North American lichens, from California, sent to him by E. Hasse. He has also named several other species collected by Hasse, and has examined a large number of my specimens, naming several, of which few have yet been published. The late Dr. F. Arnold, of München, devoted three papers to the lichens of Labrador and Newfoundland, 1896-1899. Though these papers record 175 species from Labrador and 367 from Newfoundland, I can find only a single new species recorded. When such able lichenists as Wainio and Arnold examine such large collections from America and find so little that is new, we are disposed to think that possibly the finding of new species is sometimes due to limited knowledge of these already described. However, this remark can have no bearing on the work of early students of our lichen flora when few species were known, nor is it directed toward the recent work of Stizenberger and Zahlbruckner on the comparatively little known lichen flora of our western coast, nor at that of the latter on the flora of Iowa and Minnesota, where new species surely are to be expected. Just here it may be recorded that of some three dozen Lecidioid lichens recently submitted to the student of the group, T. Hedlund of Upsala, and of the most obscure American material that has come to my hands, he returns not a single new species, though three are not yet reported as to species.

My bibliography is not yet in a condition to give exact numbers of new species by these European workers on our flora in the present period, but including some 75 species described by Nylander within the present period, the whole number of species added to our lichen flora by foreigners

since 1888 is not far from 230, all in the nature of additions to our flora as known to Tuckerman.

Turning to American workers of the period, we may consider first John Macoun, of Ottawa, Canada, most of whose work was done in the previous period, beginning as far back as 1877, but culminating in his "Catalogue of Canadian Lichens," 1902. In this catalogue is given a list of 614 lichens with notes on distribution and habitat. Macoun is not wholly given to lichenology, but during the last thirty years has, with his other collecting and study, accomplished a work that must be regarded by all future students of the lichen flora of northern United States and British America.

Next comes W. W. Calkins, a man possessed of a genuine love of nature and who has done telling work not only on our lichens, but on seed-plants and fungi as well. His first papers on lichens appeared in 1885, and he has since published eight short papers and "The Lichen Flora of Chicago and Vicinity," 1896. This last paper is an important contribution, consisting of a short historical sketch, a descriptive catalogue of the 125 lichens of the area and the first bibliography of lichens published in this country. But Mr. Calkins will be remembered rather as a keen-eyed collector of plants, who, after doing a large amount of general work in the south, devoted himself entirely to the lichens during his last few winters in the south, added greatly to our knowledge of the lichen flora and discovered 26 new species. Calkin's species have been widely distributed in the last few years and are to be found in many American herbaria.

J. W. Eckfeldt began his work in 1877 and has since determined largely for various collectors, but his first paper appeared in 1886, and following this the "Catalogue of the Lichen Flora of Florida," published with Calkins in 1887. This is a list of 330 lichens, of which 8 are new and named by Nylander and Willey. But Eckfeldt's most important contribution is "An Enumeration of the Lichens of New Foundland and Labrador," 1895, in which he lists more than 450 forms and gives descriptions of three

of his own new species and one each by Hulting and Arnold. In some of Eckfeldt's other papers (in Bull. Torr. Bot. Club) I find 25 new species described. His titles number 13 only, but he has a wide knowledge of lichen species.

The first paper by Clara E. Cummings appeared in 1888, and since that time she has published several papers, has collected largely in New England and California and has done a large amount of work in determining for other collectors. Her chief work, however, has been in the distribution of exsiccati known as "Decades of North American Lichens," and a second edition under the name, "Lichenes Boreali-Americani." The work of determination of the specimens sent out has been largely done by Miss Cummings, except for the aid given by T. A. Williams during the last years of his life, and frequent use of the sets for study and comparison has demonstated that the work is very carefully and accurately done. This critical and time-consuming work has given Miss Cummings a wide knowledge of lichen species, and American botanists may very justly look to her for more good work in a field where labor of the best quality is much needed. Her recent paper, "The Lichens of Alaska," is one of the best contributions of the period.

T. A. Williams' first paper appeared in 1889, and he was a frequent contributor till his death in 1900. Papers on the Nebraska, the Mexican, the Black Hills and the Bahama lichens are his principal contributions. But his work with Miss Cummings on the exsiccati also aided greatly during the few years that he was connected with that work. Everything done by him bore the stamp of critical study, and his early death was a serious loss to American lichenology. His titles number 13.

Albert Schneider's first paper appeared in 1894, and during the next few years several papers appeared in the Torrey Bulletin. However, these are unimportant when compared with his "Text-book of General Lichenology," which appeared in 1897 and constitutes the most important contribution to lichenology by an American since

Tuckerman. The departure from Tuckerman's classification and especially the change in generic limitations seem in the main to be an improvement, while the chapters on morphology and physiology can not fail to be helpful to all students of lichenology. All in all the book is one of the most helpful contributions to lichenology. However, to some just criticism which the work has received, I may be permitted to add that careful studies of the thalli and apothecia of some 500 species of the genera given in the text has shown plainly that a considerable number of the statements and drawings intended to bring out generic characters are surely based upon the examination of a small number of species. Finally, Schneider's briefer "Guide to the Study of Lichens," which appeared in 1898, will surely prove valuable to the beginner in the study of lichens.

H. E. Hasse, of California, has in recent years contributed largely to a knowledge of the lichen flora of his State. His first paper appeared in 1895, and quite a number has been added since. In these papers Hasse has listed 434 lichens from California and the coast islands. Of these 96 were new to North America and 64 new species. Dr. Hasse has had the aid of Stizenberger, Nylander and Zahlbruckner, and the work still in progress has already added more lichens to our flora than any other of the present period.

The first paper by the present writer appeared in 1895, and others have followed at frequent intervals, aggregating 24 titles and about 500 pages. For the work in Iowa, 226 species have been published from various parts of the State. The vicinity of Fayette, Iowa, the only area in the State even fairly well studied, has yielded 205 forms which have been published, while a number of other species from the region and recently determined as old or new species, have not yet been published. Thus it is apparent that our knowledge of the lichen flora of Iowa is yet quite incomplete. The work in Minnesota is much more complete, the whole number of forms listed being approximately 500. However, while this is the largest number of

lichens yet given for any State, a complete compilation for Massachusetts would surpass it, and I have already committed myself to the statement that there are probably 700 lichen forms within the boundaries of Minnesota. The work has added 30 new North American forms, of which ten are new, and has added about 130 lichens new to the interior of North America, or to the Mississippi valley. The Minnesota papers and some others have contained extended contributions to geographical and ecological distribution. Also may be mentioned an American and European distribution of exsiccati reaching approximately 15,000 specimens.

G. J. Pierce began his work in 1898, and his contributions to morphological and physiological problems are important as is also the paper by W. C. Sturgis on "The Carpologic Structure and Development of the Collemaceae and allied Groups." Also, during the last three years, Mrs. Carolyn W. Harris has been contributing to "The Bryologist," a series of illustrated articles, which must prove very helpful to beginners in the study of lichens. Finally, it is with regret that I simply record the names of E. E. Bogue, H. A. Green, Chas. Mohr, A. C. Waghorne and A. B. Langlois, all of whom have contributed to our knowledge recently through their collecting or writing. Also A. M. Hue's "Lichenes Exotici," published in 1892, should have been mentioned with other works by Europeans, as American students of distribution must refer to it constantly, nor has it been possible in the time allotted even to mention every helpful paper.

It is not possible in the present state of knowledge to give the exact number of species of our lichens described since Tuckerman's time, or to give exactly the whole number of lichens added to our flora since 1888. However, the whole number of lichen forms added is not far from 360, and the number of new ones 265. This gives us a lichen flora of approximately 1,600 species and varieties. However, the post-Tuckermanian work is by no means to be regarded as merely additions to the flora, for the work of Schneider and the morphological, physiological and

ecological papers are surely more important. The titles for the present period number 222, or one more than half of the whole 443 known titles for the four periods.

The bibliography of North American lichens published by Calkins in 1896 numbered 122 titles. To this the present writer added 101 in a paper published in 1898, making a total of 223 down to the date of Calkin's paper, April, 1896. Since then the work has gone forward till my number is 433, including all obtainable to the present time, but by far the larger number of additions being from obscure places prior to 1896. Still a new title comes to light frequently, and the bibliography is not yet ready for publication with this paper. Among the 443 titles, are quite a number concerning the lichen flora of our arctic regions, which have not been mentioned in this paper. While these are all minor papers, the number of species listed in them is upward of 300 and adds considerably to our knowledge of the lichens of the region.

The facts brought out in the discussion of the present period show that a good deal has been accomplished in the few years. However, several of the workers of the period are still busy with their studies, and the information regarding their work must be taken as in no sense final or complete. Also it should be stated before concluding that there is not an area of considerable size on the American continent which will not still yield lichens new to the region, and that our knowledge of the lichen flora as a whole is still quite meager. However, there is also great need of serious studies in the various genera, not one of which has yet been monographed for America. And while all this is true, morphology, physiology and ecology will all continue to furnish American workers with labor quite as interesting and productive of results.

In closing it may be repeated that it is not supposed that the bibliography upon which this historical statement is based is more than approximately correct and complete; and it is certain that some errors of statement have been made, while very possibly something of real importance may have been omitted from the discussion. It is to be

hoped that the bibliography may be published at an early date, and in the interval any suggestions from botanists as to omissions or errors in statement will be very welcome and will receive careful consideration. Finally, in closing I wish to express my thanks to many American and European lichenists, and to other botanists of our country, who have answered many questions and aided in looking over literature. Also I am under obligations to the lichenists of two continents for the photographs from which the lantern slides shown were made.

APPENDIX.

At the last moment it has seemed best to give some statement regarding bibliography; and since it is impossible to give a complete statement of all titles with adequate explanation as to contents in all instances, it has seemed best to add here the names of all authors in whose papers anything regarding lichens has been found. With these names appears the year in which the first article by the author containing any reference to North American lichens appeared, and this is followed by a figure indicating the number of such titles by the author. While this presentation is not all that could be desired, it is hoped that it may prove useful to workers in American lichenology; and I shall also be glad to aid any especially interested from my bibliography cards which give full data. The whole number of articles indicated by the numbers after each author's name is considerably more than 443. This is due partly to a repetition in instances of joint authorship, and in part also to the finding of some additional titles and authors after the address was delivered. Finally, I shall be very greatly obliged to botanists for any additions to the authors or numbers of titles indicated, or for any earlier dates of publication of any thing containing references to lichens by any of the authors.

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THE ANIMAL CELL IN THE LIGHT OF RECENT WORK.

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With the discovery of the centrosome, microscopical work on the animal cell apparently reached its culmination. It was predicted that further study would yield little more than the details of larger facts already known. The last few years have marked the addition of just such details in even greater measure than was imagined; but it is also true that altogether unexpected contributions have been made from work along other than classic microscopical lines. Especially to be mentioned are: (1) the application to the cell of the data and the methods of physical chemistry; and (2) the extension of experimental biology to the field of the animal cell. The solid facts derived from these newer studies are already numerous, with every indication of vigorous growth occurring daily. But before the full value of these new facts can be appreciated, they must be coördinated with the older conceptions. Probably at no time following the reorganization of the cell-theory by Max Schultze in 1861 has there been more urgent need for a critical survey of results than the present moment. The writer does not claim completeness for the paper here presented; the space prescribed is all too limited for even a complete summary. Rather, the attempt has been made briefly to outline certain facts which have an important bearing on some of the modern problems of the animal cell.

I. THE MINUTE STRUCTURE OF PROTOPLASM.

Any conception of cell-life must involve the microscopical architecture of living substance as such. The oldest view, and the one still widely current, presents protoplasm as everywhere having the structure of a reticulum holding more fluid matter in its meshes. The accuracy of this conception could not be tested before optical apparatus had been somewhat improved, and until the effects of laboratory reagents upon the microscopical appearance of protoplasm had been thoroughly grasped.

Hardy took a step in the right direction through his fine studies of the structure of colloidal solutions and the effects of reagents upon them. Fischer, in a series of carefully planned researches, applied our common fixing and staining agents, in accordance with biological usage, to proteids, proteoses, and peptones. Such work demonstrated that our laboratory methods, when blindly followed and implicitly trusted, are productive of altogether misleading pictures in stained and mounted preparations.

Logically, the next contribution (although historically antedating the studies just noted) was made by Bütschli from his investigations of artificial foams and emulsions, and in the application to protoplasm of the results so obtained. It was thus made clear that a series of *alveoli* would optically present the *reticulum* described by Heitzmann, Leydig, Carnoy, Schäfer, and Watasé; or the *fibrillae* of Flemming and Schneider, when protoplasmic currents and optical conditions are favorable; or the *granules* of Altmann, when nodes are emphasized, or when the reagents employed are productive of clumped artifacts. It was certainly a marked advance to have it shown that the earlier attempts to find exact uniformity of ultimate protoplasmic structure amid all diversities of living conditions were but partial expressions of one truth.

Building on the foundation laid by Bütschli, the Andrews in "The Living Substance" and later papers have brought to completion a conception of protoplasm which may well endure. It is a weighty discovery that the walls

of Bütschli's alveoli are themselves vesicular, the vesicles forming an infinitely graded series down to the extreme range of microscopic vision; and, further, that there is the most ready interchangeability from one size of vesicle to another. All structural features of the cell, when optically dissected, are seen to be due to vesicles in a matrix. Protoplasm thus embraces two series of structures: (1) the *continuous substance*—the matrix, the active part, everywhere continuous throughout the cell, optically uniform; and (2) the *inclusions*, held by the matrix of continuous substance, infinitely heterogeneous as to size and constitution—solid, liquid, or semi-liquid—arranged in a great variety of ways. The microscopical appearance of any protoplasm is determined by the character and arrangement of its inclusions. Differences of structure and function are due to differences in the inclusions. Vital phenomena may be conceived to result from the interaction between the continuous substance—everywhere uniform, and the inclusions—everywhere varied.

This conception of protoplasm as a microscopical substance illumines, as with a flood of light, the phenomena of cell-life. We are thereby prepared for an understanding of the entrance of matter into the cell; of the translation of matter from one point in the cell to another; to grasp the basis of the chemical reactions which occur in the cell; to realize how the results of irritation spread so readily; and to find a physical basis for the unity of the organism.

II. THE CHEMISTRY OF PROTOPLASM.

It certainly is significant that the elements composing living matter are not scattered at random through the natural system, but that they comprise a fairly well-defined group, characterized by low atomic weights. The extreme lability of protoplasm as a substance is doubtless the direct outcome of the instability of the compounds which these very elements tend to assume.

Not less significant is the fact that protoplasm is a watery substance, holding certain salts in small quantities.

It is worthy of special emphasis that the chemical reactions of the cell invariably occur in a liquid which is really a dilute solution of electrolytes. Free ions certainly have to be reckoned with in the phenomena of cell-life.

Among the organic constituents of the animal cell, the proteids must be accorded first place. These exist in several degrees of complexity. The simple globulins and albumins are found in both cytoplasm and nucleus; these represent the lowest step in the process of assimilation. Combined proteids hold a larger place in cell-life, particularly the members of the nuclein series. Chromatin is a nuclein rich in nucleic acid, relatively poor in proteid. Its richness in acid is expressed by the deep stain which it assumes with basic dyes. The nucleolus has a lower percentage of nucleic acid, a higher percentage of proteid. Nucleo-proteids are characteristic of the cytoplasm, a maximum of proteid having combined with the nucleic acid. It is highly suggestive that the successive additions of proteid to the molecular constitution of the nucleo-proteids of the cell take place from the chromatin outward into the cytoplasm.

Lecithin and cholesterin are components of both cytoplasm and nucleus. The place of lecithin may be next to that of the proteids in order of importance. Its presence in quantity in nervous tissue is the basis for the ready absorption and specific action of anæsthetics.

The carbohydrates and fats of the animal cell are marked off sharply from the foregoing classes of constituents by the fact that they are limited to inclusions in the cytoplasm.

A proper interpretation of the conditions for cell-life requires us to hark back to the fundamental work of Graham on colloids. Because of the high percentage of proteids in the cell, the bulk of protoplasm consists of colloidal matter in water. Following the nomenclature of Graham, protoplasm is a sol; and since the colloidal particles are held suspended in water, protoplasm is really a hydrosol. Protoplasm exhibits the properties of colloidal solutions generally, passing readily into the gel condition,

a hydrogel. Protoplasm, moreover, presents the most complete reversibility of the process, the sol passing into the gel and the gel back into the sol again, so long as conditions for vital phenomena persist. The importance of this fact in the life of the cell has not as yet been fully grasped by biologists generally.

No less fundamental is the recent brilliant work of Hardy on the conditions which are productive of gelation in colloidal solutions. A sol of proteid was used, and it was made clear that the gel state is produced by the addition of electrolytes but not by non-electrolytes, unless these act chemically; and that the gelation from electrolytes is due to the electric charges carried by the ions was demonstrated by the identical results following the use of an electric current from a battery. Moreover, the signs of the electric charges carried by the ions,—positive or negative,—determine the movements of the colloidal particles, keeping them in suspension as a sol, or causing them to fall into the gel condition. For example, a sol having its colloidal particles negatively charged will pass into the gel state upon the addition of positive ions, or the introduction of the positive electrode of a battery.

These remarkable results indicate the importance of ions in the life of the cell, and they also serve to clarify many phenomena hitherto quite obscure. The rapid changes in the consistence of protoplasm have long been known from observation, but they have never been explained; these fascinating alternations of more rigid and more fluid conditions are now seen to rest upon the state of the colloids of the cell, the controlling factor being the ions set free as the result of chemical reactions. Peculiarities in the toxic effects upon protoplasm of certain substances have long been a puzzle; but such effects are now recognized as due to the electric charges carried by the ions rather than to the chemical nature of any particular substance employed.

III. THE NUTRITION OF THE CELL.

The ingestion of matter, standing as the alpha of cell-life, may well command attention. It is somewhat unfortunate that laboratory studies of the Protozoa exhibit so prominently the entrance of solid matter into the cell, for this condition is really quite rare in the animal series. Matter is so universally floated into the cell in water that the problem of its entrance is, in fact, the problem of the absorption of a solution. The field is a promising one for further research, but sufficient has already been done to show that the principles of osmotic pressure find application here. The architecture of protoplasm and its chemistry are such that conditions for a greater or less amount of osmotic pressure are always present. Now, since food reaches the cell in solution, van't Hoff's work on osmotic pressure shows that its absorption is not a peculiarly mysterious phenomenon, but that the vital results are in harmony with the principle of the conservation of energy. Even the choice of matter, so universally exercised by the cell, rests on relative osmotic pressures, depending upon the peculiar constitution and chemical reactions of the protoplasm in each instance.

The transforming effects upon matter of enzymes hold so necessary a place in animal life that attention has long been directed to this field. Here again, the understanding of the principle involved places the biologist in the debt of the physical chemist. The study of colloidal solutions or sols of metals has been illuminating to a remarkable degree. Platinum, gold, silver, iridium,—when brought to an extremely minute state of subdivision, by methods which need not here be described, behave as catalyzers to such an extent that these sols have been called "inorganic models of the enzymes." An enzyme is, of course, immensely complex in composition as compared with the inorganic model, being the result of cellular activity—a nucleo-proteid; but its minute subdivision is certainly at least as important as its chemistry.

In the metabolism of matter, the proteids assuredly have the pivotal place. The assimilation of proteid involves the reconstruction of the molecule,—"aggregate"—upon an altogether different plan, whereby a state of the greatest instability is given. The condition for this instability is the intramolecular introduction of oxygen.

The members of the nuclein series begin with nucleic acid, a compound of phosphoric acid and the nuclein bases adenin, hypoxanthin, guanin, and xanthin. Of these bases, adenin is fundamental, because its molecule contains no oxygen, and the other bases are derivable from it. Adenin may be looked upon as of the utmost importance in synthetic processes, since under conditions of reduction the oxygen-free adenin may be transformed into a new body with avidity for oxygen; and this, in turn, may be again transformed by the addition of new "aggregates." Hence adenin may be the starting-point in the synthesis of nucleins of successive grades,—the nuclein of chromatin, that of the nucleolus, and the nucleo-proteids of the cytoplasm. That nucleins do arise from the synthesis of simple proteids and phosphates has been shown by Miescher in the salmon, where the muscles are converted into the material of the ova during the ascent of the fish to the breeding-grounds.

The study of the nuclein series points to the nucleus as the center for the initial syntheses. The many instances of the reciprocal relations between nucleus and cytoplasm here receive almost startling explanation. The work of Mathews on the pancreas-cell demonstrated the origin from the chromatin of fibrils of nucleo-proteid which are spun out into the cytoplasm. We appear to have here, before our very eyes, the basis of the "intracellular pangenesis" of de Vries. Place beside this result the work of Loeb on the seat of oxidation in the cell, and it is clear that the nucleus holds a controlling place in cell-life because synthetic steps are initiated there. We are thus enabled to appreciate the significance of the position assumed by the nucleus in the growing cell; the changes in the microscopical appearance of the nucleus during

periods of cell activity; the dependence of the cytoplasm upon the nucleus in regeneration experiments; and the real value of the nucleus in the field of heredity. This does not mean that the nucleus is more important than the cytoplasm in cell-life, for the two stand in a mutual relationship necessary to each other.

The importance of lecithin in metabolism has been shown by the feeding experiments of Hatai. This substance evidently represents a distinct step in the process of assimilation in the animal cell.

The absence of carbohydrates and fats from the nucleus signifies that these substances are transformed and split up entirely in the cytoplasm. The place of proteid in metabolism, then, may be regarded as primary; that of the carbohydrates and fats as secondary.

In the field of excretion there is less of experimental evidence to serve as the basis for an adequate conception, and it is probable that quite diverse mechanisms must be recognized. The work of Dreser is very suggestive, however, showing that excretion from the cells of the uriniferious tubules may be calculated on the basis of osmotic pressure.

IV. THE TRANSFORMATION OF ENERGY IN THE CELL.

Animal biology may begin to claim recognition as an exact science. It has passed beyond the merely descriptive stage and has demonstrated beyond question that the principle of the conservation of energy really holds in the activity of the animal cell. Potential energy is introduced into the cell from without along with the matter of food and oxygen. Foods are substances whose elements have a relatively feeble affinity for each other as compared with the affinity which each element has for oxygen. The accurate measurement of the potential energy of foods is necessarily recent; the determination of the kinetic energy of the organism, even more so. But the difficulties have been overcome by the intelligent co-operation of many workers:—the efforts of Atwater and his collaborators should be especially mentioned. We stand today on a

secure foundation of fact, not inference, that chemical energy is the only source for the energy appearing in the animal cell in its several kinetic forms—heat, light, mechanical work, electricity.

The production of heat and light in the animal cell involves transformations most readily understood. Just as oxidation in a physical system other than the living transforms the potential energy of organized matter into heat, so, in the animal cell, heat is the direct outcome of the chemical transformations of dissimilation. Since light and heat are but different phases of the same radiant energy, so the basis of light-production in the cell is the same as for heat-production. Experimentally, the oxidation of fatty granules in the presence of an alkaline medium yields light. Special phosphorescent organs are cell-groups where such fatty particles, resulting from metabolism, are burned in an abundant supply of oxygen. It is possible that light is a more widespread accompaniment of cell-life than is usually supposed.

The transformation of chemical energy into the mechanical energy of movement is slightly less direct, involving surface tension. Experimental work with oil-drops shows that amœboid movement is the simplest condition and should be taken as the starting-point. An amœboid cell has its surface unspecialized, permitting freedom of movement. With surface tension equal at all points, the form of such a cell must be that of a sphere. It is evident that a local alteration of surface tension must result in a corresponding change of form at the point where alteration occurs. Reduction of surface tension will be expressed by the formation of a pseudopodium; increase of surface tension by its retraction. Now, the chemical changes occurring in living matter provide the conditions for the alteration of surface tension. The introduction of oxygen increases molecular instability, leading to the reduction of surface tension and the protrusion of pseudopodia; reconstruction of the molecule must, conversely, increase surface tension, causing the retraction of pseudopodia. Thus the phenomena of movement result from local differences

of chemical action. Recent work has made it clear that ciliary movement, and the still more specialized contraction of a muscle-cell, are derivable from the simple conditions just sketched.

Electricity is an invariable accompaniment of vital processes, whether in the contraction of a muscle-cell, the secretion of a gland-cell, the changes of nervous matter, or the truly striking discharge of a specialized electric organ. Electrolytic dissociation is the basis for the development of animal electricity in all its fascinating guises, chemical reactions continually altering the relations of ions. Differences of potential are due to the fact that not all parts of a cell or group of cells are active at the same time. It has long been known that protoplasm acquires an acid reaction as the result of its activity. In terms of physical chemistry, this fact means that positive hydrogen ions are set free. Such ions migrate from the active into the passive protoplasm more rapidly than do the anions, hence the regions where vital processes are taking place remain negatively charged, as all our experimental work has long shown.

V. THE IRRITABILITY OF PROTOPLASM.

From the standpoint of cell-chemistry, the irritability of living matter is nothing more than the modifications induced by external conditions in the course of the transformation of matter and energy in the cell. A modern high-explosive is just as truly irritable as is protoplasm, having the equilibrium of its matter and energy disturbed by the impact of kinetic energy from without. In the case of living matter, the external energies productive of such disturbances are called "stimuli," a somewhat unfortunate term. Obviously, the effect of stimulation,—the introduction of kinetic energy from without,—is to divert the course of chemical reaction in the cell, causing a corresponding change in the kinetic energy liberated,—movement, heat, light, electricity. The change in the electrical condition necessarily influences the behavior of the colloidal particles

of protoplasm. Mathews would find the basis of conductivity in a wave of gelation in the colloids of irritable tissue.

"Taxis" or "tropism" in its several forms is today seen to result from the unequal stimulation of a cell at its opposite poles. The minuteness of the possible differences between the strength of stimuli at the two extremities of a cell is best seen in chemotaxis. But however small this difference, if it be sufficient to affect the transformation of energy at the pole proximal to the stimulus, unilateral movement must result. Hence the wonderfully fascinating directive effects of external agencies upon the lower organisms rest upon local differences of chemical reaction in the cell.

Work on the motile Infusoria has indicated in a very striking way the nature of a reflex. Whatever the form of stimulus,—mechanical, thermal, chemical, electrical,—the same reflex is exhibited. This reflex is itself invariable, embracing an arrest of the forward progression, a swimming backward, a turning toward a structurally defined side, then a swimming forward. Such a reflex is entirely effective under the usual conditions for the life of the animal, because the anterior extremity first comes in contact with sources of danger, and the series of movements leads to the danger being avoided.

An insight into adaptation to environment has been given by the fine work of Jennings upon fixed Infusoria, particularly Stentor. Here it was shown that protoplasm has results wrought into it from the previous experiences to which the organism has been subjected. The behavior of Stentor during the course of repeated stimulation soon begins to show traces of after-effects from the stimuli which have just preceded. Such adaptation to conditions must have its basis sought in alterations produced in the architecture and chemistry of protoplasm under the impact of energy from without, the modification of structure persisting for a greater or less time. The field is certainly a fruitful one for further and more refined investigation.

Nervous tissue is rapidly developing an extensive and highly ramified literature of its own. The tendency is current, on the part of at least a few neurologists, to neglect the boundaries of the nerve-cell altogether, placing emphasis, instead, on the continuity of neuro-fibrils throughout the entire nervous system. It may safely be said, however, that a healthy condition of the subject will require proper recognition of cell-values.

VI. THE REPRODUCTION OF THE CELL.

The phenomena of development are recorded in a literature which has become truly voluminous, but only during very recent years has the work passed beyond the purely descriptive stage. Experimental embryology has made very rapid progress, however, and the achievements already to its credit are so noteworthy as to give promise of a brilliant future.

Fertilization is now definable as a distinctly twofold process. The factor first recognized, the transfer of chromatin, has long been known in the most minute detail. The other factor, but recently distinguished as such, is the stimulus to development which results from the entrance of the spermatozoön. Oögenesis leaves the ovum in what may be called the first critical stage of the organism, in which the living material has reached a condition of such stability that death soon occurs unless the stimulus of fertilization be given. This stimulus is conveyed by the spermatozoön normally; but the experimental studies of Loeb and others have made it clear that a variety of stimuli may be productive of artificial parthenogenesis. A change of osmotic pressure, even mechanical shock, will induce development from this critical condition. Eggs which are normally parthenogenetic find the stimulus proper to their development amid natural surroundings, without the intervention of fertilization at all.

A few lines of work are now to be touched very lightly, and the bare mention of others must be omitted altogether. In the field of mitosis, the models of Heidenhain have at

least furthered our understanding of the mechanism involved. Experimental methods have shown that astral rays and spindle fibres are rows of vesicles spun in the cytoplasm, expressive of currents or lines of chemical action. That much-discussed thing, the centrosome, is no longer considered a definite morphological body, but rather a center for a special transformation of energy, to be induced at points in the cell other than the normal ones under certain conditions. The division of the cytoplasm certainly involves a localized change of surface tension; and the forms assumed by the individual blastomeres during cleavage involve surface tension as one of the factors.

The studies of Wilson, Driesch, Morgan, Lillie, Conklin, Boveri, Crampton, and others on localization in the egg are among the most important of modern times. Begun for the purpose of putting to experimental test the hypotheses of Roux and Weismann, this line of work has long since outgrown its original impetus, and has illumined some of the deepest problems of the cell. Differentiation, as these studies have shown, is a feature of the cytoplasm. It is in the nature of a progressive change, whereby the cytoplasm of the egg becomes ever more and more localized into definitive regions, it may be very early in the history of development. Cleavage is merely a means of dividing up this material into cell-units; the exact process is relatively unimportant, differentiation lying far behind cell-boundaries. Localization, while thus cytoplasmic in character, is really determined from the nucleus, and is carried out in the cytoplasm through specific metabolisms which are set up. There is more than a simple parallel between the course of determination and the course of synthesis in the cell. Chromatin is the center for the initial steps of both, and the nucleus holds a definite place in development because of the place it holds in metabolism.

The energy of growth is indeed a conspicuous feature of the developing cell. To say that growth occurs because of the introduction of material from without is a mere truism; the forcible expansion of the cell is indicative of an energy

which lies behind the entrance of matter. The energy of growth is but a special instance of osmotic pressure, the rhythms of which are expressive of the metabolisms in progress.

The life-history of the metazoan cell involves many successive divisions, the earlier mitoses occurring rapidly, the later ones more and more slowly. There finally comes a time when the cell reaches its second critical stage, a condition of stability whose end is death. The first critical stage has been averted in the history of each organism through fertilization; but in the second critical stage, such a stimulus is clearly impossible for the metazoan cell. The work of Calkins on Paramœcium, however, has demonstrated that an artificial substitute for conjugation may be found for the infusorian cell,—meat broth, extract of brain or pancreas,—whereby the second critical stage is passed. The bearing of this result on the metazoan cell is obvious. Probably certain tumors represent cells which, having approached the point of stability, have been stimulated to renewed activity by the presence of unusual ions.

VII. CONCLUSION.

Students of the animal cell may well look upon the results of modern work with no small degree of satisfaction. A large body of solid knowledge concerning vital processes has grown up during recent years, very different from the vague and even mysterious assumptions which lurked here but a short time ago. One conclusion to be drawn from the facts established is the marked degree to which physical principles have been extended into the domain of the vital. Some workers, as Le Dantec, swing the pendulum to the farthest limit in this direction, seeing nothing but *mechanism* in the life of a cell. Others there are, who, unable fully to appreciate the physical basis of cell-life, insist on pushing the pendulum to the opposite extreme, calling this position *vitalism;* a position "where", to quote Kant, "reason can repose on the pillow of obscure qualities."

The question properly may be asked, how rapidly is the investigation of the cell nearing its goal. Such an end is

as yet far distant; du Bois-Reymond declared that it could never be attained at all. To-day, we know certain phases of cell-life fairly well, but the obstacles in the way of further progress are more serious than those already surmounted. However, the biology of the cell has by no means reached a dead-point; we have but just begun to make full use of the data afforded by sister sciences; the experimental method has yet rich treasures to yield. We assuredly are justified in concluding that one field after another will continue to be reclaimed from obscurity in the future just as in the past, and we reasonably may expect a working conception of cell-life ultimately to emerge from modern investigation.

Iowa City, April 14, 1904.

THE IMPORTANCE OF VITAL STATISTICS IN THE STUDY OF SOCIAL SCIENCE.

BY GERSHOM H. HILL, M. D.

Social science is now studied in all colleges and universities. Professors who have qualified themselves by years of post graduate work both at home and abroad show pupils how to study history in a topical manner. Statistics, ancient and modern, are compared. Large and well stocked libraries are in demand. Public documents, reports of State institutions, both charitable and penal, are examined. The data desired are compiled and used. Inter-society and inter-collegiate debates, upon popular questions, are frequently held. The most learned men available are asked to be present and serve as judges. In the study of science, theories are admissible only when facts can not possibly be obtained. In the study of social science, statistics are indispensable. In order that they may be of greatest value they must be gathered and reported by discriminating and unbiased minds, at the same time they should be complete and accurate. Guess work and prejudice vitiate statistics. In addition to more than a dozen State institutions in Iowa, we have a State association of charities and correction. The work of looking after the poor and the otherwise unfortunate part of the population in the larger cities is now thoroughly organized; existing conditions are investigated, and discretion is exercised in giving relief. Suitable homes are provided for orphans, for the aged, and for the "boys in blue." The largest cities in this country, as well as many

others, have excellent hospitals, almost innumerable, and general hospitals are now being established by the Catholic and other churches in Iowa. Even in towns of but a few thousand inhabitants there are private hospitals owned by the surgeon in charge. Now, not only students, professors in colleges, clergymen, and various philanthropists, are studying sociology, but in Iowa the members of the Board of Control of State Institutions, the superintendents, and wardens in these institutions, the secretary of city charities, and the general secretary of the Y. M. C. A., learn by experience that "prevention is better than cure." Co-operation is practiced, and all persons engaged in this kind of work are anxious to learn the causes of poverty, intemperance, prostitution, crime, suicide, insanity, other diseases, and degeneration. In this manner the generous public, which has the burden of supporting these various institutions, will learn how to prevent misfortune, and how to reduce the number of its dependent class to a minimum. For an example, the question is often asked, "Is insanity increasing in our state?" In order to secure intelligent and trustworthy information on this subject, we must turn to the hospitals for the insane. In these hospitals careful attention is given to statistics. Here this disease is being studied in a thorough and scientific manner. Here we can learn to what extent the insane are foreign born, or the children of foreigners. Also to what extent heredity is the cause of this disease, and whether either parent of a patient was intemperate, or vicious, or degenerate. Again we look to the hospital to inform us to what extent education and religion are factors of producing, or in preventing insanity. What occupations were the insane engaged in? Are the single or married more likely to become insane? Is city life or country life more conducive to insanity? Should harmless and incurable insane persons be permitted to live at home, or all of them, always be cared for in state, in county, or in private institutions? In order to make the statistics concerning unfortunates most valuable, the enumeration of the population outside of the institu-

tions should be thoroughly taken, so that reliable comparisons can be made and correct conclusions drawn. Statistics have been used ever since there were states; first by the government to number the fighting men, next to ascertain what amount of taxes should be levied on the remainder of the population. Statistics, or rather the material for statistics, existed at a very early period, but it was not until within the last three centuries that statistic use of the information available began to be made for purposes of investigation, and not for administration only. What we now call vital statistics was first known as "political arithmetic," and began to be used in England about the middle of the seventeenth century. Statistics is defined as a collection of facts, tabulated and classified, respecting the condition of society in city, in state, or in the country. *Vital* statistics pertain to health, disease and mortality.

MARRIAGES.

I have in my possession the Sixty-fourth Annual Report of the Registrar-General of births, deaths, and marriages in England and Wales for the year 1901. I learn from this volume, of more than 300 closely printed pages, that the number of marriages during that year was 259,400, corresponding to a rate of 16 married persons per 1,000 of the estimated population. This rate was slightly below the average for the past 40 years. What seems most remarkable is the uniformity of rate during all these years. The slight decrease of the rates for 1900 and 1901 was probably due in some measure to the war in South Africa.

In accordance with the marriage act of 1898, which provides that under specified conditions, marriages may be solemnized in registered buildings by certain duly authorized persons without the attendance of a Register of Marriages, there are 25,000 certified places of worship. There are more than 15,000 churches or chapels of the Established Church in which marriages may legally be solemnized. There are also more than 13,000 buildings registered for the solemnization of marriages by rites other than

those of the Established Church. The denominations to which these buildings belong are Methodists, Congregationalists, Baptists, Catholics, and Jews. The registered buildings which had been supplied with marriage register books were distributed among 426 registration districts. There remained 210 registration districts within which *no* register building had been brought under the operation of the new law. The *forms* of marriage in England and Wales during that year, were 666 per 1,000 solemnization according to the rites of the Established Church, and 334 per 1,000 were contracted otherwise. Of the *men* who married during the year, 903 per 1,000 were bachelors, and 97 were widowers. Of the *women* 928 were spinsters and 72 were widows.

Ages at Marriage. The proportion of re-marriages has decreased year by year since 1876. Among the persons who married in 1901, 50 per 1,000 of the husbands and 160 per 1,000 of the wives were minors. During recent years there has been a decline in the proportion of marriages of persons under age. Of the over 500,000 persons who married in 1901 only 1 per cent of each sex failed to make definite statement as to age. As recently as the year 1881 precise statements of age were made in only about 5-6 of the marriages. The mean ages at marriage deduced from such imperfect data could only be regarded as rough approximations to the true mean ages of all who married. As the proportion of stated ages has increased the approximation has been brought closer. In the case of marriages between bachelors and spinsters the difference between the means of the recorded ages and the means of all the ages both of husbands and wives can not possibly exceed a small fraction of a year. In cases, however, in which one or both of the parties have been previously married the greater proportion of unstated ages leaves room for a much greater possible error. The *mean age* of those who get married now in England is greatly increasing. At present it is 26½ years for bachelors, and 25 for spinsters.

Signatures in Marriage Register. The marriage registers show a further reduction in the signatures by mark, both

of bridegrooms and of brides. The proportion of illiterate men formerly was 194 per 1,000 marriages. It has fallen until it is now only 25 per 1,000. The proportion of illiterate women was formerly 268, it is now only 29. In 1901, in only 8 per 1,000 of the marriages did both bride and bridegroom sign by marks. In 17 other cases only the bridegroom signed by mark, and in 21, only the bride signed by mark. Quite a proportion of the marriages among illiterate persons were traced to foreign born Jews. Among the whole number of persons who married in the year 1901, 416 are described in the Marriage Register as having been previously divorced. I also have for reference the sixty-first Report of births, marriages and deaths in Massachusetts, for the year 1902. It is a paper bound volume of 250 pages and prepared by the Secretary of the Commonwealth. In Massachusetts in 1902 the number of marriages registered was 25,685 which was 794 more than the number registered in 1901 and 1343 more than the number of 1900 and was greater than in any of the previous years since the beginning of registration. The number of persons married for each 1,000 of estimated population was 18. In England it is 16. The highest proportion of marriages in the last 50 years occurred in the year 1854 when 25 persons in every 1,000 of the population were married, and the lowest in 1878 when 15 persons in every 1,000 were married. The average for 50 years is 19. In Massachusetts 30 per cent of the marriages occcurred in the last quarter of the calendar year, which contains the holidays. 29 per cent in the second quarter consisting of April, May and June. In the third quarter which contains the hottest weather only 23 per cent of the marriages took place, and in the first quarter of the year, characterized by the coldest weather, only 18 per cent of the marriages are consummated.

In the study of marriages, like insanity, statistics ought to tell whether marriages are increasing or decreasing; whether city or country people are more likely to marry; whether persons who marry now are not older than those

who married 50 years ago. In the study of certain phases of social science it would be desirable to learn how the tendency to marry in Iowa compares with other states and with other countries; to what extent men and women marry three, four or five times. Again in the study of social science in this country it is desirable to know whether natives or foreign born persons are more likely to get married, and to what extent the blood of Yankees and foreign born people is getting mixed. Whether marriage between whites and blacks is increasing, and whether by this method progress is likely to be made in solving the race problem. By referring again to the Massachusetts vital statistics we find the marriage rate of Massachusetts as compared with various foreign countries per 1,000 population as follows: Russia 91, Hungary 89, Massachusetts 87, Germany 85, Belgium 83, Austria 82, Spain 81, United Kingdom 80, Switzerland 77, France 76, Holland 76, Italy 74, Norway 72, Sweden 62. In my opinion if it were not for the large standing armies in foreign countries, which we do not have in the United States, the marriage rates would be greater abroad than they are in Massachusetts, or in most of the states in this country. It is to be remembered furthermore in this connection that the population in Boston, and in the manufacturing cities of Massachusetts is now made up to a very great extent of foreign born population and of the children of foreigners. The Massachusetts vital statistics report also contains a chapter and several tables concerning divorces applied for and granted. It appears that in the year 1902 the whole number of divorces granted was 1,480, which number is greater by 537 than the average during the last 20 years. Twenty per cent, about the usual number, were granted on the ground of adultery, 46 per cent, which is 1 per cent less than the average, was granted on the ground of desertion, 70 per cent of the divorces granted were on the complaint of the wife.

BIRTHS.

The number of births registered in Massachusetts in the ear 1902 was 72,219. The rate was less than in any year nce 1882. Fifty years ago the rate was 29 births to 1,000 f population, now it is 27. Doubtless economic condiions of the population has an influential effect on the umber of births by increasing or decreasing the number f marriages, but to what extent it is difficult to deterine. The birth rates for Massachusetts are compared vith several foreign countries. Russia has the highest irth rate, and France has the lowest. The rate per 1,000 nhabitants is as follows: Russia 49, Hungary 29, Austria 7, Germany 35, Great Britain 29, Massachusetts 26, France 22. The percentage of native born children has lecreased with considerable uniformity during the last 20 years, and it is also true if a longer period of years is taken nto account. It is observable that the male births always predominate. This is a general rule and obtains in European countries as in the United States. The greater mortality among males more than offsets the numerical preponderance of births of the males and results in a tendency to an increase in number of females.

DEATHS.

The report contains a statement of the mortality of Massachusetts compared with that of the countries of Europe. It is to be noted that the death rate in Massachusetts is less than in any of the countries except Norway. The rate per 1,000 inhabitants was, Russia 32, Spain 29, Germany 22, France 20, Great Britain 18, Switzerland 17, Norway 16, Massachusetts 16. It is observable that while the death rates have decreased largely in cities they have not decreased in the same ratio in the rural districts of Massachussets. The effect of the advances made in medical science and in sanitation, and in the preventive and restrictive measures enforced by the health authorities is much better illustrated by examining the comparative rate for registration cities in this country than by compar-

ing the rates of the whole state. The decrease in the general death rate due to disease most frequent in the early years of life, on the one hand, and in the increase in the rates due to this disease occurring generally in advanced ages, on the other, mean also increased longevity. Physicians in studying vital statistics are more interested in the causes of death than anything else. Now the causes of death are so skillfully and thoroughly classified that much valuable information can be obtained from the study of vital statistics especially those of large cities. I have at my disposal a chronological summary of Chicago mortality covering a period of 60 years, issued annually by the department of health for Chicago. Besides Dr. Arthur R. Reynolds, the commissioner of health for Chicago, issues a bulletin once a week which is mailed to all physicians in Chicago, and to many others who are interested in this line of work. In it comparisons are made with the previous week, and with the corrosponding week one year ago. At the end of each month, and of each year comparisons are again made and averages determined. We learn from Chicago statistics that there has been no Asiatic cholera in the city for 30 years, and that mortality from cancer is rapidly increasing. While mortality from cholera infantum and from diphtheria has greatly decreased during the last few years. The mortality from tuberculosis continues to gain ground; influenza, generally known as La Grippe, did not appear in Chicago until 1890, when a general epidemic in this country prevailed. The greatest mortality from this disease occurred in 1895, and the mortality was twice as great in 1901 as in the year 1902. The percentage of deaths from pneumonia is steadily increasing from year to year. The table illustrating the statistics for smallpox shows that the worst epidemic occurred in 1874 when the percentage of mortality was 6⅓ per cent. In 1894 the mortality was 4⅓ per cent, in 1895 there were no deaths reported from this disease in Chicago, and since that year there have not been more than a dozen deaths from this loathsome disease. Contagious diseases and

other epidemic diseases are the ones in which philanthropists in company with physicians will always take a deep interest, but probably the vital statistics concerning death, which the students of social science will be most likely to investigate and philosophize about are those which result from *violence.* The percent of death from violence to deaths from all causes in Chicago was 2 in the year 1851, 7 in the year 1901. The average per cent of deaths from violence to deaths from all causes during the last 52 years was 4. Such deaths are grouped under the following heads: By accident, by suicide, by manslaughter, by railroad accident, by street car accident. As a matter of course deaths from accidents will increase with the amount of labor saving machinery used, and with the amount of traveling done on railroads, and with the increase of electric street cars, which run at rapid rate, and are well patronized. The vital statistics in which I am personally interested, and am the most inclined to investigate are the deaths by suicide, and the deaths by manslaughter, together with the physical, mental, social, commercial, and religious influences attending them. I trust that in the foregoing paper I have sufficiently illustrated the nature of vital statistics to show that they can be studied to great advantage in certain lines of social science. In closing I wish to urge upon the members of the Academy the need of adequate laws and methods of gathering and of recording vital statistics in Iowa, so that they may be fully and accurately secured and made accessible to philanthropists and to scientific students who may wish to use them. It is to be hoped that such a law, as there is on the statute books in the commonwealth of Massachusetts, and in some of the other states, will be enacted by the Thirty-first General Assembly of the state of Iowa, so that in time, the vital statistics of this state may be satisfactorily compared with the vital statistics of other states and countries.

A GEOLOGICAL SITUATION IN THE LAVA FLOW, WITH REFERENCE TO THE VEGETATION.

BY HARRIET M. CLEARMAN.

This great lava flow extends over a great part of Idaho, Washington, and Oregon. The area covered is extensive, some 200,000 square miles. That this flow has considerable depth may be seen at Shoshone Falls, and at various places where the river has cut a gorge. That there were successive flows with intervals of rest between may also be seen by a river gorge, for in the walls are fossil roots and stumps. Further than this but little has been written concerning this wonderful field.

To those who know the character of this region I shall need to offer no apology for the inadequateness of my investigations. The chief obstacles to the work were, first, the lava, which was utterly impassable in many places; second, the lack of water; and third, that the region had not been surveyed. The distances consequently are only approximate, and the whole investigation which was made in 1899 and 1900 is merely offered as a suggestion.

In Idaho the Snake river flows entirely in the lava region; and from near the source to beyond Shoshone Falls, more than one-half the distance across the State, about 450 miles, there is no tributary from the north. Here are a number of volcanic buttes but they could hardly be the source of so vast a quantity of lava, so the theory of earth fissures should hold good here.

In the eastern part of the Snake river desert is a portion designated on the map, Rolling Plains, Sand and Lava. The sand is a very great obstruction. The plains are more or less sandy until the sand-hills or dunes are reached. These form the most conspicuous feature of this region. At a distance of about 60 miles they have the appearance of a low mountain range, peculiar in the fact that their color is strikingly white against the darkness of the farther mountains. On closer inspection they are somewhat darker, the sand being composed of quartz crystals mixed with particles of lava. The range is estimated to be 30 miles long and from 3 to 8 miles wide. Some of the dunes reach a height of 300 feet; on the windward side they are gently sloping and ripple-marked by the wind, while the other side is perpendicular. These large dunes stand entirely alone and travel independently—the rate of travel varying with the velocity of the wind. They have been known to advance one foot per day. They are approaching the Snake river, and whether they are strong enough to cross the stream or if their sand shall be washed away by the swift current will be known by the future. I have given these only a brief mention because of their conspicuousness, and because of their obstruction to other investigations.

Starting from Saint Anthony and traveling in a northerly direction, after the first mile or so the lava plains are exceedingly rough and bare except for the sand and the sagebrush which is more or less scanty. In this course for about 12 miles it seems to be apparent that there were several lava flows, for one flow seems to overlap another, the successive margins marked by an abrupt cliff or shelf; each succeeding terrace being marked by less weathering and hence by less vegetation.

In this distance five of these shelves were counted, then suddenly appearing in the midst of this lava waste, in a slight depression or basin, is a fertile tract very springy and marshy, covering probably 2 or 3 sections, which is entirely surrounded by the lava desert with no sign of

water for at least 12 miles. In contrast with the sagebrush growth of the desert here is a luxuriant vegetation. The trees are mainly *Juniper* and *Populus angustifolia* and *P. tremuloides.* Sedges are many, and among the flowering plants were two species unlike anything found along the desert streams, for all of these streams on the south side of the river have a similar vegetation: but here is a species of orchid growing abundantly,—*Spiranthes romanzoffiana;* the nearest locality in which we found it was Stanley Lake in the Sawtooth mountains about 500 miles away. The other was a species of gentian, a low, one-flowered plant, unlike any other species found and unlike anything described in the northwest flora.

Beyond this basin is what seems to be the latest of these flows; it is but little weathered, hard and sharp, just as the writhing, twisting, swirling mass cooled, apparently unchanged since the eruption.

Following up the grade of this flow we found a breaking in of the surface lava. We descended about 20 feet and discovered a series of chambers or caves. They were about 100 feet long more or less, with a width of 20 feet and an arched roof 10 feet in its greatest height, and about 2 feet where one communicated with another.

These caves were doubtless formed in the cooling of the lava; as the surface cools first the flowing continues below, thus forming these cavities.

As the surface crust was broken down in several places we were able to follow one series for about a quarter of a mile. In one chamber which had direct communication with the outside, was a floor of ice, which by the light of lanterns afforded a unique skating pond. The temperature must have been at the freezing point, although it was the middle of July and outside the thermometer stood at 110°, in the sun, for there was no shade. Our course in these caverns was finally obstructed by a flowing stream which utilized these cavities for a bed.

Beyond this plain, coming down from mountains, are a number of lost rivers, so called because they disappear in

sinks in the desert. Now these lost rivers are directly in the slope down to the fertile basin and between lie the lava caves; so the inference is drawn that the water of these lost rivers is conducted by such subterranean channels to places like the fertile basin described, and probably to the Snake river itself.

THE FURCULA IN THE COLLEMBOLA.

BY J. E. GUTHRIE.

The Collembola or "Spring-tails" comprise a very interesting order of wingless insects, usually associated with the order Thysanura, and frequently placed in that order.

These little insects are common under bark and stones and among loose debris, wherever they can find dark, moist hiding places. As they range from less than 1 to only about 4 millimeters in length, and are usually very agile, we seldom notice them when collecting unless we are looking especially for them.

In Iowa, the Collembola have been but little studied as yet. I have taken at Ames about 18 species representing 12 genera. The order, and, in fact, many of its species is of world-wide distribution.

The wingless condition of the Collembola is usually regarded as primitive, and thus these insects acquire an interest as throwing light, possibly, upon conditions which obtained among ancestral insects.

Imagine a wingless ancestor which had already become a hexapod, that is, had the three pairs of thoracic legs developed for ambulatory purposes as is the usual condition in the group today. Picture to yourself the segments of the abdomen of this insect as each possessing a pair of jointed, leg-like appendages, such as we may still find in more or less modified form in many aquatic larvae and in the adults of some of the species of Thysanura proper.

From such a primitive stock let us suppose the Collembola to have branched off.

The abdomen of the Collembola possesses six somites and it is upon the third and fourth of these that the appendages were found useful and were retained. The pair which remained upon the fourth somite has been specialized into a very efficient organ for leaping, variously known as the "furcula," "saltatory appendage," "spring," "spring-gabel," and "tail." The appendages upon the third somite have become an organ known as the "tenaculum" or "catch," accessory to the furcula.

This specialization of organs for springing is analogous to the super-development of legs for leaping in the fleas, flea beetles, crickets, etc.; only that in the Collembola organs having no other use are specially set apart for the purpose.

The furcula seems to be a pair of three-jointed appendages which have their basal segments joined together, side by side, to produce one median basal piece. This first segment which is usually more or less flattened and often shows characters indicating its double origin is called the manubrium. Figs. 1 and 2. From the distal end of the manubrium proceed two parallel or divergent pieces called the dentes, and each of these bears at its distal end a short segment called the mucrones or mucro. The mucrones usually bear one or more teeth of various forms and in various positions.

The history of the development of the furcula seems to have followed a law which might be stated thus: "A pair of similar organs which habitually work together and only in the same direction, tend to become united, beginning at their bases." Doubtless the development of the normal labium in the class Insecta from a second pair of maxillæ to a united organ will fall under this law.

In many of the Collembolans the furcula is apparently an appendage of the fifth somite, and has been so regarded by Sir John Lubbock and several other writers upon Collembola. It was held that in the Family Entomobryidæ, the appendages of the fifth somite were represented, and

that therefore the furcula in that family was not really homologous with that of the Poduridæ which bear the organ upon the fourth somite. I can not agree to this view. The furcula seems to me to belong to the fourth somite, and to be merely shunted backward in some cases to a position beneath the following segment. Its muscle attachments, I think, indicate its true position. In several genera of the Entomobryidæ the fourth somite has a tergum considerably longer and larger than that of any other somite of the body. Perhaps this great development is for muscle attachment as it is among these that the furcula reaches its maximum development.

The furcula is provided with flexor and extensor muscles, the latter being the stronger. As the furcula is usually carried with its ends pointing forward, these strong muscles are normally tense and ready always for a spring. To counteract this tension and to hold the furcula in position, the "catch" or "tenaculum" on the third somite is provided with two short, roughened blades which pass down between the bases of the dentes, close to the manubrium and then close up under them, turning outward to either side, thus holding the furcula up close to the body. The short leverage obtained by these blades enables their muscles to balance the more powerful furcula extensors. Fig. 6 and 7. The whole device is a simple one, yet so effective that in Achorntes boletivorus, a species common on decaying mushrooms, I have seen leaps of about fifty times the animal's own length; and this species has by no means a well developed furcula when compared with many other Collembolans.

It is interesting before going farther to compare with the Collembolan furcula, the condition and use of some of the abdominal appendages found in another form. One of the most active of Thysanura is the Machilis, a genus which I think has not yet been recorded from our State but which I have taken several times along the Mississippi river bluffs in Minnesota and Wisconsin. This insect has a 10-segmented abdomen, and eight of these somites beginning with the second, bear each a pair of small,

jointed appendages. The largest pair is the pair borne by the eighth somite and I think that these are usually carried directed downward like the furcula. This Machilis not only runs swiftly but leaps with great agility by means of this pair of appendages, possibly aided to some extent by the others.

The Collembolan furcula varies considerably throughout the different genera, and the shape of its terminal segments, the mucrones, afford excellent specific characters in many genera. See figs. 3, 4, and 5.

Some curious and beautiful adaptations have taken place to suit different modes of life. For instance, in the more active species living a rather free, roving life as the Smino-thuridæ and many of the Ento-Mobryidæ, we find the organ usually long, slender and very supple, reaching forward in some cases almost to the head. Fig. 8.

In some of the heavy bodied species among the Poduridæ, the organ is short and stout and far stiffer in proportion to its length. Fig 9. These are species which usually inhabit places more or less enclosed as spaces under bark, in worm holes, etc., where there is less room to use a longer spring. In Xenylla the spring is weak and apparently not much used while in Friesia it has almost disappeared by atrophy, I suppose. Fig. 10.

Some Collembola grouped together in the Family Aphoruridæ are without the furcula entirely, but they are generally found in situations where the springing power could rarely be exercised. As the gradations of atrophy in different genera and species are so complete, I have little doubt that their habits are responsible for the loss of the organ from disuse. Thus I would hold that their springless condition must not be looked upon as primitive and I therefore regard them as regressive rather than as ancestral members of the group.

I might mention one or two of the most remarkably modified furculas. Some of our species of Sminthurus live on the surface of ponds and have a fan-like furcula. Fig. 11. The manubrium is short, broad and flattened and the dentes diverge widely. On the outer and inner sides of

the dentes are borne rows of long, strong hairs or bristles which present an almost solid surface to strike the water. The mucrones are of very unusual form, being flat and spoon-shaped and with their ends turned in toward each other. In another unrelated genus we find a modification for the same purpose which differs somewhat. Fig. 12.

In this species, Podura aquatica Limie, the manubrium is extremely short and each dentes has an outward direction from its base to near its middle where there is a bend that appears almost a joint. Beyond this bend, the dentes turn inward again. The mucrones are flattened somewhat as in the Sminthurus just mentioned.

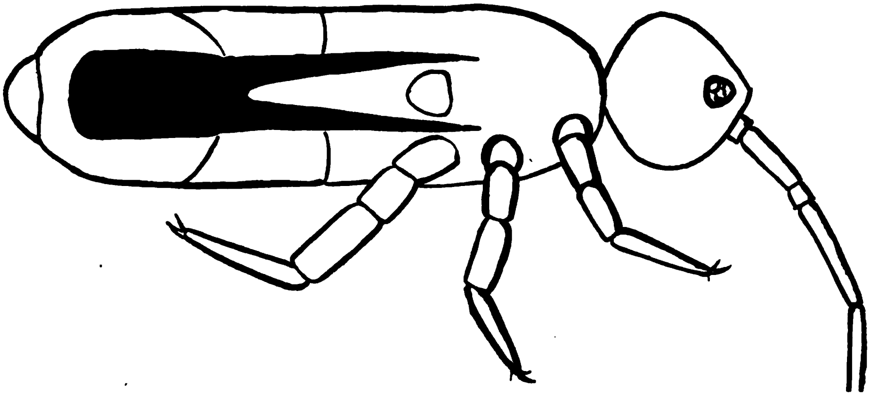


Fig. 1.

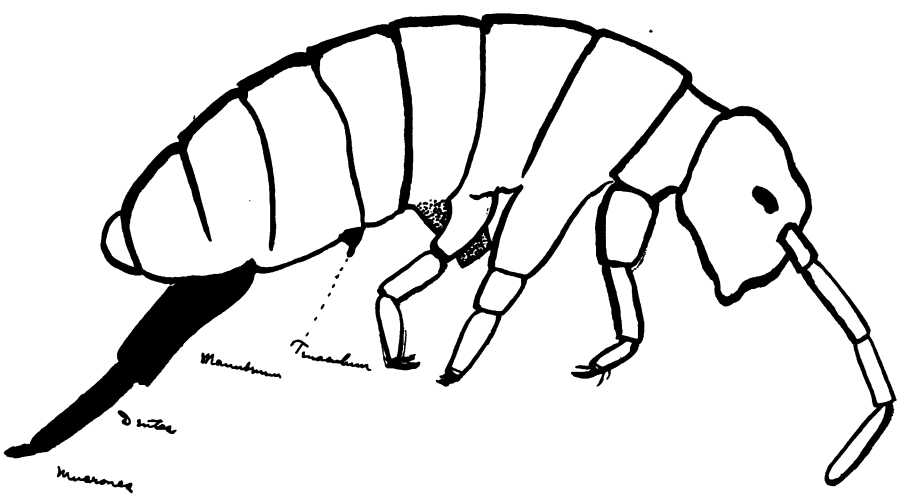


Fig. 2.

PLATE III.

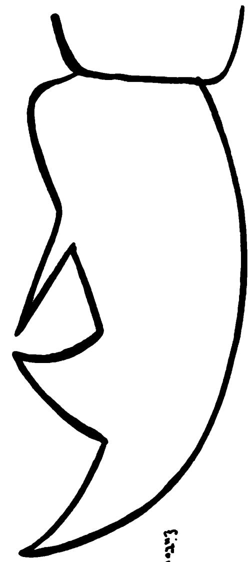


Fig. 3 Entomobrya

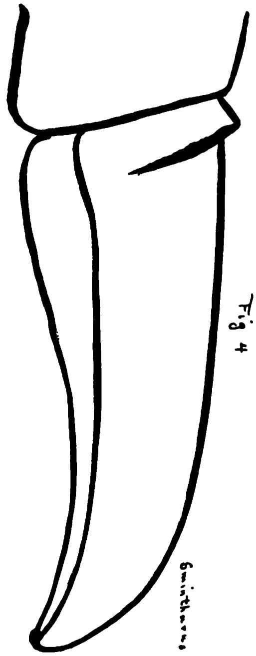


Fig 4 Sminthurus

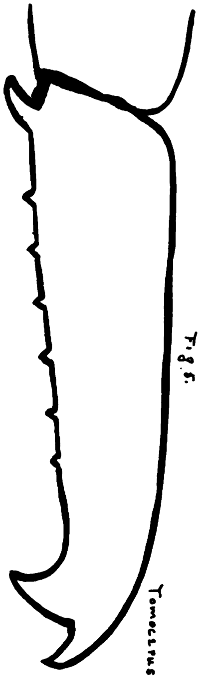


Fig. 5 Tomocerus

Fig. 6.

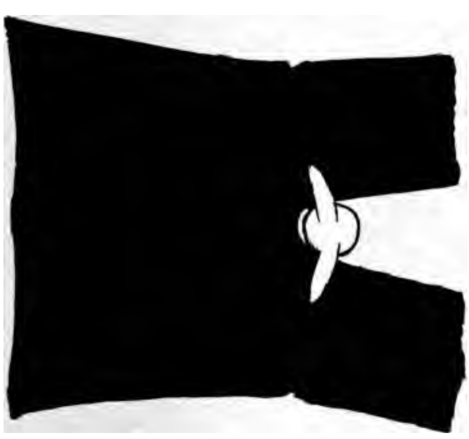
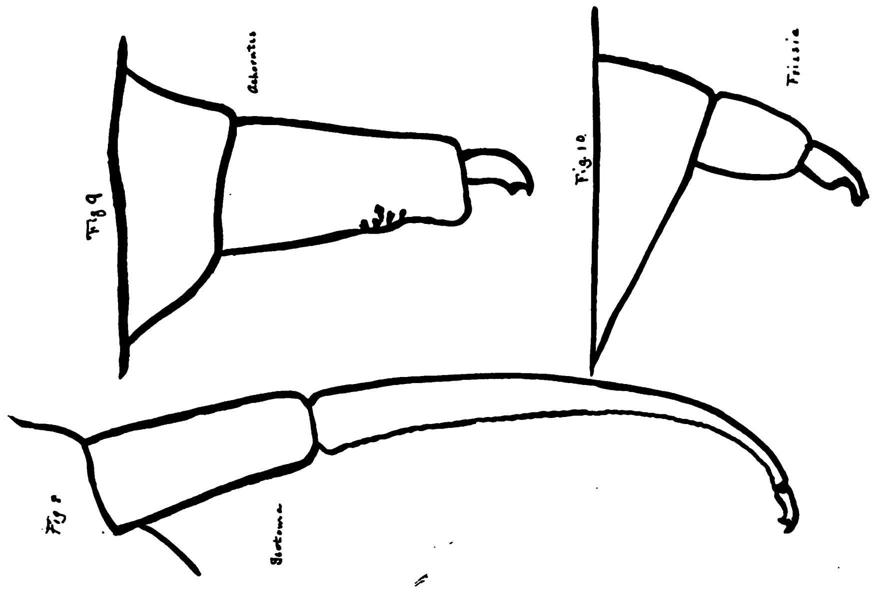


Fig. 7.



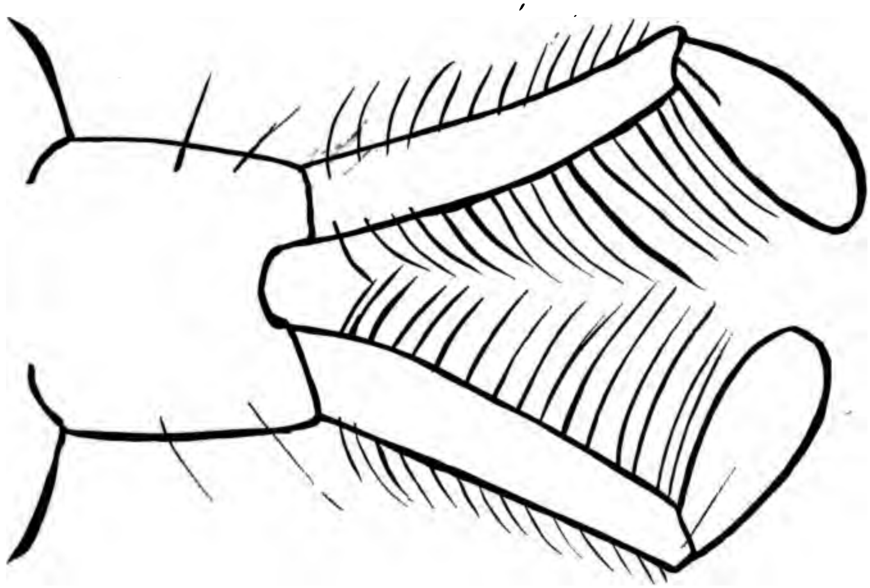


Fig. 11.

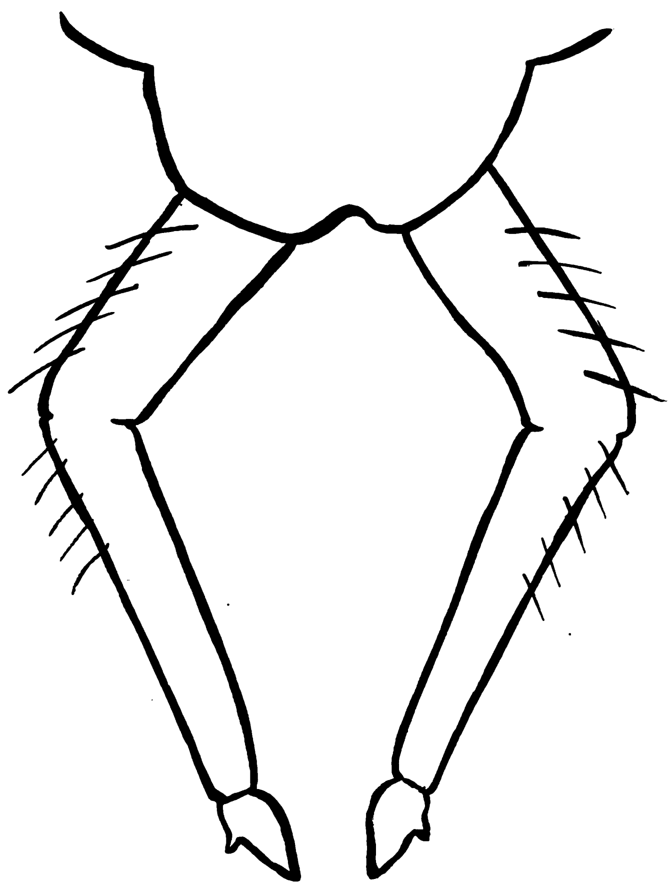


Fig. 12.

STEREOSCOPIC PROJECTION IN NATURAL COLORS.

BY C. F. LORENZ.

The projection of pictures on a screen in such a way that they shall show relief, like that given by a stereoscope, has been accomplished by two methods, one of which depends on the use of polarized light, and the other on the use of color-filters. The following is an account of a modification of the latter method, which enables us to see the projected picture in relief, and at the same time in the original colors. A signal lantern is used.

As is well known, to make a natural-color lantern slide by the method of three superposed positives, three negatives are taken from the same point of view, through red, green and blue-violet color screens respectively; from these are made positives which are colored in the shadows and clear in the high-lights, the one from the red-record negative being cyan-blue, that from the green-record negative being magenta red or "pink," and that from the blue-violet record negative being yellow. Now let one of these negatives, say the green-record, be taken from a slightly different point of view; the pink print will then not register with the other two, and the resulting picture will be blurred. But when the screen is viewed through a pink glass over one eye and a green glass over the other, then the picture will stand out in relief, provided that the pink and green glasses are held respectively over the proper eye, because the pink picture will be invisible to the eye covered with the pink glass, while the picture formed by the combination of the yellow and the cyan-blue prints will appear to this eye as a picture black in the

shadows and pink in the lights. Similarly, the latter picture will be invisible to the eye covered with the green glass, but the pink picture will appear to this eye as a picture black in the shadows and green in the lights. Thus the condition for stereoscopic vision, which is that the one eye shall see only the one picture and the other eye only the other picture, is fulfilled. It might seem at first thought that the differences in the pictures due to the fact that the negatives were taken through color-screens might cause a difficulty, but experiment shows that the relief is perfect. The prints should be made to register in the background.

Now, since certain colors are prevented from entering each eye it follows, of course, that each eye alone can not see a natural color picture, but since the one filter transmits just what the other stops, the brain will get the correct colors provided that it can combine the color sensations. Although ordinarily when we attempt to combine in the brain color sensations received by the two eyes there occurs what is called color rivalry, there being a predominance first of one and then of the other color, yet under the conditions here described, where the attention is fixed by a picture, the brain seems to have the power of making the combination. At any rate, experiment shows that when the viewing glasses are of the proper relative density, then the picture is seen not only in bold relief, but also in its natural colors.

Such a stereoscopic transparency also shows well when viewed through the colored spectacles directly, instead of being projected. Prints on paper similar to the well-known "anaglyph" prints could also be made.

Evidently, instead of using green and pink for the spectacles we can use either of the other primary colors together with its complementary, namely, red and cyan-blue, or blue-violet and yellow, the negative taken from the displaced point of view being in the former case the red-record negative, so that the cyan-blue print is the odd one, and in the latter case the blue-violet record negative, so that the yellow print is the odd one.

A CONTRIBUTION TO OUR KNOWLEDGE OF THE DEVELOPMENT OF PRUNUS AMERICANA.

BY R. EARLE BUCHANAN.

There is no field more promising of results and none that has received less attention until recently than the investigation of the more hidden life histories of our cultivated plants. The gross anatomy of these plants has long been studied. Later we learned of their relationships through a study of their grouping and classifications. Lastly, the microscope with all its world of technique has been brought to the study of the various plant structures. The best and most nearly perfect or ideal treatment of our cultivated plants can be attained only when we know all that is possible regarding their life history and their structure; for all have their bearing on the problem of production, fruitfulness, fertility and hybridization. In no other group of plants is this more true than in those to which we give the most intensive culture, such as our horticultural crops, especially the orchard fruits.

The early cytological investigations were purely scientific in character, their object the general furthering of our knowledge of life histories and the tracing of relationships. For this purpose a few plants have become almost classical, but almost all of these were non-economic. From a study of these forms the greater part of the foundations of our knowledge of embryonic development has been laid, and the details of the superstructure

of particular instances remain alone to be constructed. In recent years many interesting and puzzling questions have been raised regarding the life histories and the development of many of our cultivated plants. Several investigators have undertaken studies of a few of these problems, and their results have been most instructive and valuable. The contributions which Cannon (5) has made to the study of plant hybrids, especially in the maturation of the germ cells of the hybrid peas is important as an addition to our knowledge of the working of the Mendelian laws. Dr. Webber through his investigations of xenia in maize has contributed much to our knowledge of the immediate effect of pollen on the ovary, and has settled one of the most puzzling of cytological and practical problems. Attention has been given by various investigators also to the subject of fertilization in some of our cultivated plants and its bearing on their fertility. Among many might be mentioned Profs. Beach and Booth (3) (4) (27), of the New York State Agricultural Experiment Station, who have studied the microscopic appearance of the pollen of the grape and its relation to fertility, their results being most interesting and valuable.

One of the groups that has received some little attention of late years has been that of our cultivated plums. There are many interesting problems connected with their pollination and fruiting, their self sterility and their cross pollination. Several phases of these problems have been worked up by botanists, and horticulturists, most prominent being Prof. E. S. Goff, of the University of Wisconsin, and Prof. F. A. Waugh, of the Vermont Agricultural Experiment Station. The former has made a number of investigations relative to the abortion of pistils in the plum, its frequency and cause. He found that a large per cent of the pistils of the Americana group of plums are abortive, that is, with pistils incapable of producing fruit. Professor Waugh, through a series of years has studied quite exhaustively the percentage of abortive pistils, and the problems of pollination in plums. These will be discussed in another connection.

One of the objects of the work undertaken in this connection was that of throwing some light upon the time interval between pollination and fertilization in the plum. It is a common belief among nurserymen and horticulturists that although the pollen is applied to the pistil and germinates, fertilization and consequent development of the embryo is delayed for some time. This necessitated a study of the pistil, ovule and embryo sac in their development. A few observations were also made on the per cent of aborted pistils in the different plums, and a study was made of these aborted pistils to determine, if possible, whether the trouble was structural. Observations were further made on the different problems that are connected with pollination, fertilization and development, including a study of the aborted ovule that is to be found in every normal plum ovary.

For a study of the early development of the flower buds, material was gathered during the fall and winter and sectioned free hand. As soon as the buds began to swell in the spring, the material was gathered and hardened in Chromic acid or Platinic chlorid for twenty-four to forty-eight hours. It was then washed, infiltrated and imbedded in paraffin, and cut in serial sections. The most satisfactory stain was the triple stain of Anilin Safranin, Gentian Violet, Orange G. Many other combinations were tried, but none were more satisfactory. Material was gathered daily just before and during the blooming season, and thereafter every second or third day until the embryos were mature. The Wyant, one of the Americana plums, and the Poole's Pride, one of the Wild Goose type. were the forms taken for study.

According to the observations made at Ames, the first indications of the formation of the flowers is to be found in the fruit buds in the axils of the leaf a little before the middle of July. This agrees well with the observations of Professor Goff in Wisconsin [9] who finds them formed about this time. These flowers make their appearance first as slight swellings on the interior of the bud near the

tip of the shoot. They slowly enlarge and the pistil and floral envelops with the stamens grow out from this little knob or swelling. The floral envelops grow more rapidly than the essential organs, and so come to enclose them as in the mature flower buds. A single pistil is formed, and numerous, usually twenty, stamens are born on the calyx. From one to five, usually three, flower buds are formed in each bud. There seems never to be a flower formed at the tip of the growing point in the bud, that is, no terminal flower is formed. This has led Goff [9] to decide that the flower cluster is a corymb.

By the beginning of winter the flowers are well formed, the calyx, corolla, stamens and pistils well differentiated. Plate III. The appearance of the bud at this time is represented in Fig. d, a longitudinal section of the bud of the Wyant made December 8, 1903. It will be noted that the stamens and the pistils are well developed, the two ovules showing as projections from the walls of the ovary.

It is evident that an abnormal season of weather at the time of the formation of these flower buds might have an influence on their abundance and strength as well as in cutting down the reserve food stored up for their use the next season. These abnormal conditions might arise as the result of drouth, defoliation, insect and fungous enmies, etc. Then again a season may be very favorable to woody growth, and the tree expands its energies in that direction rather than in the formation of flower buds. Too much emphasis must not be laid upon these, however, for Goff [9] has found that the dropping of the leaves one year does not seriously affect the fertility the year following, yet he concludes that the conditions of the previous summer are very potent as factors in the determination of the formation of fruit buds and the yield.

During the winter there is little change, the flower in all its parts remaining entirely dormant. That this may be a critical time for the flower of some varieties is very probable. The consensus of opinion among horticulturists seems to be that the winter's cold is often the cause of a shortage in fruit, and the failure of many varieties to bear.

This conclusion is reached by Speer[18] in regard to the Minor plum, which failed to fruit at Ames for him, though fruiting abundantly farther south. Goff also holds this opinion, but Waugh [22] declares that this is not tenable, as, with the exception of one location which had a uniformly high percentage of defective pistils, he found that the percentage of defective pistils decreased rather than increased northward. Craig[7] gives the percentage of fruit buds injured during the winter of '98-99 in Iowa, and finds them to vary from 0 per cent to 100 per cent in different varieties and localities. Goff[10] kept records of the variations in temperature during several winters, and studied the effect of variations in temperature on the buds. He comes to the conclusion that very often cold weather does much damage. Lord [16] goes so far as to claim that the abortion of pistils in the plum is caused entirely by unfavorable climates.

During the latter part of March or the first of April growth is resumed in the flower. Should a cold period intervene at this time it is undoubtedly true that a large share of the pistils are killed or rendered abortive. The pollen mother cells separate, and by the middle of April the buds are noticeably swollen, the anthers increase rapidly in size, as do the pistils and the ovules. Early in May the blossom opens. The flower varies much in different varieties. The single pistil is one celled and bears two ovules. There are usually about twenty stamens arranged in a double ring. The dehiscence furnishes an abundance of pollen. In the normal flowers of most of the varieties cultivated at Ames the pistils and the stamens are about the same height. In several forms, notably the Wyant, the inner row of stamens opened first, sometimes preceding the outer stamens by a day or more. Pollination normally takes place almost immediately and the pistil ceases to be receptive. Pollination is brought about almost entirely by the common honey bee (*Apis mellifica* Linn). Much has been written concerning the adaptations of Prunus for cross-pollination.

The time of blossoming, that is, the period of full bloom, for the tree usually lasts from three to five days, or even longer in unfavorable seasons when pollination does not sooner occur. Many of the experiment stations have determined the blossoming periods of the various plums at different places, Goff in Wisconsin, Waugh in Vermont, Craig in Iowa and others. These tables reveal that there is a succession of blooms in different varieties for several weeks. The stigma of the pistil becomes receptive, that is, covered with a sticky secretion within a short time after the opening of the flower. If the weather is favorable, pollination occurs within a few hours or even minutes. Any one who has stood near a plum tree on a bright day with the tree in full bloom will realize that with such a buzzing, humming host of insects as are present there is little chance that the flower will remain for a long time unpollinated. The insects that occur upon the flowers have been collected and named at several stations in the United States.

Robertson[28] gives the following list of insects found pollinating the plum in Illinois: Hymenoptera; APIDÆ; *Apis mellifica* L.; ANDRENIDÆ. *Andrena sayi* Rob.; *A. salicis* Rob.; *A. cressonii* Rob.; *A. flavoclypeata* Sm.; *Halictus lerouxii* Lep.; *H. zephyrus* Sm.; *H. confusus* Sm.; *H. Stultus* Cr.; *Colletes inæqualis* Say. Diptera. BOMBYLIDÆ. *Bombylius major* L.; SYRPHIDÆ. *Chrysogaster nitida* Wd.; *C. ustulata* L.; *Platychirus hyperboreus* Staeg.; *Syrphus americanus* Wd.; *S. ribesii* L.; *Mesograpta geminata* Say.; *Sphærophoria cylindrica* Say.; *Eristalis dimidiatus* Wd.; *Helophilus similis* Mcq.; *Brachypalpus frontosus* Lw.; TACHNIDÆ. *Gonia frontosa* Say.; MUSCIDÆ. *Lucilia cæsar* L.; *L. cornicina* F.; CORDYLURIDÆ. Seatophaga squalida Mg.: Lepidoptera. NYMPHALIDÆ. *Pyrameis atalanta* L.; *P. huntera* F.; NOCTUIDÆ *Plüsia simplex* Gn. Coleoptera; CHRYSOMELIDÆ. *Orsodachnaatia* Ahr.

Vestal and Garcia[6] found that at the New Mexico Station the honey bee ranked first in abundance and importance as a pollinator, closely followed by the wild bees. Cockerell[6] in the same territory studied the

insects found on one of the wild plums, and found that the wild bees ranked first in importance. A few Diptera visit the flowers but are of little importance. Waugh[24] gives a list of eighteen Hymenoptera and ten Diptera taken from plum blossoms at Denton, Md., Ithaca, N. Y., Madison, Wis., and Burlington, Vt. This list includes the *Apis mellifica*, Linn., several species of Bombus and eight species of Andrena. The honey bee is of the greatest importance in all cases, though several of the species of Andrena are very active. In another connection Waugh[23] gives a list of seven Hymenoptera and nine Diptera taken in Oklahoma, Maryland, Iowa and Vermont. Very few species are identical in the two lists, showing the honey bee to be probably the one universal pollinator. Collections made in the spring of 1899 at Ames were found to contain the following species:

Hymenoptera. *Apis mellifica* Linn.; *Bombus Virginicus* Oliv.; *Andrena bipunctata* Cr. Diptera. *Phobia fusciceps.*

The honey bees outnumbered all the other species ten to one. The humble bees are too scarce at this season to be of importance.

The flower of the plum secretes a large amount of nectar and this proves very attractive to the bees. In the majority of the trees the anthers and the stigmas are about on a level. The honey bee on alighting on the flower clings to the stamens, covering the underside of its body with the pollen. This is brushed off upon the stigma of the same or other flowers. There is a very marked difference in the methods used by the ordinary honey bee and the smaller bees as the Andrenas in getting at the nectar. The former forces its way into the calyx cup from above, while the latter sips from the edge of the cup, working its way in among the bases of the stamens. They are thus almost useless as pollinators as they rarely come in contact with the anthers.

In most flowers there are no special external structural adaptations to insure cross pollination, the plant seeming to rely very largely on self sterility to effect a cross. This view is not held by Heideman[15] who finds in the plum

an excellent illustration of a plant that is just changing from hermaphrodite to bisexual. He places the plums in several groups based on the structure of the flower. Those groups are as follows, the Dichogamous with some members proterogynous and others proterandrous, the Heterostyled with the long and the short styled forms, the Bisexual with flowers either andromonœcious or gynodiœcious, and the Hermaphrodite. In these forms he reads the various steps in the future evolution of the flower. It seems as though this classification was rather arbitrary, for other students of the question have been inclined to ascribe these variations to climate, etc., rather than to an inherent variability. Waugh(21) finds that some individuals are markedly proterogynous, the pistil being exposed and receptive even before the opening of the blossom, in others there is normally a lack of pistils, and still others have very long pistils. Even in this classification we are led to wonder just how much is due to a natural tendency to vary, or to abnormal changes brought about by environment; and whether these could be rightly classed as natural adaptations to cross pollination.

The length of the blossoming season depends very largely on the weather. If conditions are favorable the flowers are all pollinated within a day or two, and the petals fall two or three days later. If pollination does not occur the flower remains for several days longer.

The pollen tube is formed very soon after the application of the pollen to the stigma. It gradually descends through the tissue of the style until it reaches the ovule. The process of fertilization occurs in from one to two weeks. One of the figures illustrates the pollen grain as it germinates in a three per cent dextrose solution. The pollen germinates very readily under these conditions. The question of the relation of the temperature to the germination has been discussed by Goff (9) who finds that some varieties will germinate even in cold weather at a temperature of 51° F., and would even show some slight power of germination after being exposed to a freezing temperature. From these facts and the fact that the pollen will germinate after the

lapse of a week if kept in a moist chamber, he concludes that there is not much danger from pollen not germinating and fertilizing during cold wet seasons. The anthers of the plum will not burst during moist weather, but only in dry.

Leaving these problems, let us retrace our steps, and take up a study of the development of the pistil and its contents. At the beginning of winter the pistil is well formed, the ovary with its single cell and two ovules being evident. At this time it is about .45 mm. in length, the cells of the ovary is .21 mm. by .14 mm. When growth commences in the spring the pistil increases rapidly in size, the style becomes much elongated, and the bifid stigma appears. At the time of blooming the normal pistil is about 4.2 mm. long, the style 3.2 mm. by .14 mm., the ovary oval, and about .36 mm. by .27 mm. Structurally at this time the pistil is as follows: The stigma consists of two sticky lobes closely covered by glandular papillæ. This forms an ideal receptacle for the pollen as it is carried there by the bee. Below these papillæ there is a loose cellular tissue, and below this the tissue of the style made up of an outer cylinder of narrow cells and an inner vascular layer surrounding a central cylinder. These cells are smaller than those of the interior. The ovary is covered by an epidermis the cells of which are rectangular in cross section. The cells are for the most part small and irregular. After pollination the style withers and falls away. The walls of the ovary become thick fleshy, and the fruit ripens as a drupe from 2 to 4 cm. in length.

Late in the summer of the preceding year the two ovules made their appearance as swellings on one side of the wall of the ovary. By December they are distinctly recognizable, the ovule having attained a length of 70 microns. At this time the archesporium can not be made out with certainty. During the winter the ovule remains practically unchanged. Beginning with the latter part of April development is quite rapid. At this time it increases rapidly in size, and becomes twisted so as to become distinctly amphitropous. The two ovules seem to be identical as to size and shape,

it being impossible to identify the one which is to become abortive. The seed coats soon grow nearly even with the tip of the nucellus. The latter is relatively large. At this time great difficulty was found in studying the earliest appearance of the archesporium. Development appears to be perfectly normal, except that the embryo sac, instead of being formed near the apex of the nucellus is formed near the center, as many as ten or twelve rows of cells being between it and the apex. Mitosis could be observed in some cases, but was not studied owing to the minute size of the cells.

The macrospore is formed normally, and increases rapidly in size. When it reaches the length of about 25 microns its nucleus divides, one daughter cell giving rise to the antipodal cells, and the other to the egg cell and the synergids. The antipodal cells disappear almost immediately, being indistinguishable very shortly after formation. The endosperm nucellus is formed by the conjugation of the nuclei from either end of the sac. This stage of formation is shown in figure c, Plate II. The cells in the lower part of the nucellus increase rapidly in number and size, the embryo sac elongates in the direction of the micropyle, breaking down those cells in this portion of the nucellus, and coming ultimately to occupy a position just below the micropyle. At the stage shown in figure c, Plate II, the embryo sac is oval in shape, and rather small in comparison with the size of the egg cells and the synergids. These extend nearly half the length of the embryo sac.

The embryo sac continues to increase rapidly in size, especially in length. For a period neither the oosphere nor the definitive nucleus changes the synergids and the oosphere remaining in their place, and the endosperm nucleus moving and keeping approximately in the center of the sac. After the lapse of several days to a week, the latter begins to divide rapidly, and soon fills the entire sac with small nuclei. These do not surround themselves with a definite cell wall. At this time the embryo sac has reached a length of .525mm.

At about this time (May 14-21) fertilization occurs. There is a great deal of variation in the time, some ovules not being fertilized until a week later than some others. Thus in some cases fertilization does not occur until two weeks after pollination. Not until the first of June were the embryos large enough to be detected by the naked eye. There is thus much ground for the belief of many horticulturists that fertilization does not occur for some time after pollination. The embryo increases rapidly in size, absorbing and replacing the endosperm as well as the nucellar tissue. During the time that the embryo sac is increasing in size so rapidly, the cells of the nucellus increase in number but little, but enlarge enormously, becoming eventually many times as large. The cell walls are very thin, and the nucleus almost indiscernable, and are very readily displaced and absorbed by the embryo, which comes to fill the entire seed at maturity.

As has been stated, members of the genus Prunus have two ovules, only one of which develops. Several interesting facts were found in a study of this ovule. Until about the time of pollination there is no perceptible difference between the ovules, the embryo sacs being perfectly normal in each. Very soon, however, it is found that one of these ovules has gained the ascendency, and is developing more rapidly than is its mate. The latter is soon crowded to one side, the tissues of the nucellus become disorganized, and the entire ovule is gradually flattened against the wall of the ovary by the pressure of the other. At length it disappears. The persistence of life in the embryo sac even after the partial disintegration of the nucellar tissue was especially marked. The egg cell and the definitive nucleus with the enclosing sac, all staining appearing normal, could be distinguished even after the surrounding cells could not be recognized, and the entire ovule was shriveled. Fertilization does not occur in the other ovule until later, so that it can not be that the first ovule fertilized is the one that develops. The fact, also, that it is very rare for one to find both ovules matured

would argue that the abortion was not due to imperfect fertilization.

It is well known to every horticulturist that there are very few plums produced or matured in comparison with the number of flowers produced. This fact has been discussed by many writers, under many heads, such as self-sterility, abortion of pistils, etc.

Even a cursory examination of many of our native plums will reveal the fact that there is a large proportion of the pistils not functional or abortive. There is a great variability in the proportion of abortive pistils in different varieties and different seasons. For instance, the Wyant plum in 1903 at Ames had only 8 per cent of perfect ovaries, while the Poole's Pride the same year had 91 per cent. In 1904 the Wyant had about 90 per cent perfect or normal ovaries. Goff [14] in 1894 tabulated results of counting the abortive pistils in 22 varieties, and found them to vary from 0 per cent in the White Nicholas to 38 per cent in the Marianna. In the Wyant it was 16 per cent. Again [13] he mentions that the Moreman produced only 29 per cent perfect pistils. As to the variability in successive years he finds that the per cent of perfect pistils in 1892, '93 and '94 were 83.1 per cent, 66.1 per cent and 5.3 per cent, respectively. He concludes [11] that the tendency to produce abortive pistils is greater in the year following a heavy crop, and vice versa. The number of young plums that form after the flower varies directly as the perfect pistils. Professor Waugh has also investigated this problem with the following results:

Prunus Americana	27.6 per cent defective.
Prunus chicasa	15.1 per cent defective.
Prunus hortulana	24.6 per cent defective.
Prunus domestica	5.6 per cent defective.
Prunus triflora	15.9 per cent defective.

Lord [16] found that some trees never had pistils, while others that normally produced perfect pistils were without them some seasons. One of his shy bearers, Harrison's Peach, usually had 90 per cent of the pistils defective. Others as the Rollingstone, De Soto, etc., rarely have more than

1 per cent or 2 per cent. Bailey [2] mentions a tree of Prunus Americana that never produced pistils.

The causes for this abortion have been variously stated by different authors to be climate, lack of nourishment, or an inherent tendency toward bisexuality. Waugh enumerates them as:

1. Physiological character of the plant.
2. Age of the tree.
3. Health of tree.
4. Storage of food materials.

There seems to be a difference in different plums as to the age at which they become abortive. Examination of some flowers shows that pistils are entirely absent, in others a scarcely recognizable filament and others a withered ovary half the normal size. Some of these latter abortive ovaries were sectioned, and in most instances were found to contain a normal embryo sac and nuclei, while the tissues both of the ovary wall and the nucellus were largely disorganized. Evidently then, the archesporium was formed before the destructive influences had acted upon the ovary and caused it to degenerate. This shows a remarkable ability to grow and develop on the part of the female gametophyte. The abortion in these ovaries is certainly then not due to the lack of a perfectly formed egg apparatus.

Self sterility in the genus Prunus is very marked indeed in some of the species. It is this phase of plum growth that has probably received more attention than has any other. Especially is this true for the last ten or fifteen years. Even when the flowers seem perfect as to the pollen and the pistil, the pollen from the same plant or even from the same variety is often impotent. This condition is not confined to the genus Prunus alone, for Waite [19] after a careful study of the pear came to the conclusion that certain varieties must be cross pollinated in order to secure good fruit. The cultivated grapes have also been studied by Beach [3] [4], who finds the same thing to be true. Professor Waugh [20] covered about 6,500 flowers of Prunus Americana and P. triflora with sacks, preventing

cross pollination, and from this number only five fruits set. From these experiments he decides that all the native plums are absolutely self-sterile. That climate is a factor is evident from the fact that out of eight varieties of plums that bore fruit in 1897 in Missouri according to Whitten [25] all were self-fertile. Heideman [15] has made a very elaborate classification of the sexual affinities of the Prunus Americana and decides that the only self-fertile forms are those with hermaphrodite flowers. Fletcher [8] gives a list of varieties of plums self-sterile at Cornell, N. Y. He decided that self-sterility is not a constant character. Orchard fruits in general can not be separated into self-sterile and self-fertile varieties. Craig [7] finds many varieties that are sterile at the Iowa Station. Bailey [2] also finds varieties self-sterile. This self-impotency in the plum has caused the publication of several tables of the best pollinators for certain varieties. It has been shown that simultaneity of blooming period does not necessarily mean that cross pollination is best. Some varieties have a pronounced selective ability. Heideman [15] believes that pollination affinities may be decided by the kind of flower borne. According to his classification out of forty-nine possible cross pollinations he finds only nine or ten that are effective. It is probable that he has over-rated the importance of this factor, for Professor Waugh [24] says "All our commonly cultivated Japanese and native varieties belonging to several different species are quite reliably infertile."

Another factor affecting the plum crop is the so-called June drop. About the time that plums reach the size of a coffee bean many of them fall. It has been suggested that the June drop is due in many cases to the non-fertilization of the ovule. That this is a very plausible theory is evident from the results obtained in this study. The ovary evidently begins to develop under the influence of the germinating pollen, but if through accident fertilization does not take place, by June the fruit ceases development, shrivels and falls to the ground. In very few of these June drops can embryos be found. That there are

several other causes that operate to bring this about is undoubtedly true, but that this is one of them is also undoubtedly true.

The above work was undertaken at the instance of Dr. L. H. Pammel, Professor of Botany, and his continued assistance is gratefully acknowledged.

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EXPLANATION OF PLATES.

PLATE VI.

Fig. a. A flower of plum showing stamens of two lengths, the shorter maturing first.

Fig. b. A flower of a Japanese hybrid showing the stamens of two lengths, both maturing at the same time.

Fig. c. A flower of the Wyant plum.

Fig. d. A flower of Prunus domestica showing the slender pistil.

Fig. e. A flower of the Wolf showing a perfect pistil.

Fig. f. A flower of the Poole's Pride, young flower just opened.

Fig. g. A flower of the Wyant.

Fig. h. A flower of the Poole's Pride.

Fig. i. A flower of the Surprise.

Fig. j. A flower of the Wolf.

Fig. k. A flower of the plum showing the method followed by the small bees in procuring nectar. These bees rarely affect pollination.

Fig. l. Bee showing the pollen bags.

Fig. m. Flower of the plum showing the method of the larger bees, such as the honey bees, when securing nectar. These forms are good pollinators.

Fig. n. A flower of the Wolf showing an abortive pistil.

PLATE VII.

Fig. a. Embryo sac of the Wyant April 26. 17.5 long.

Fig. b. An ovule of the Wyant showing the deeply placed Embryo sac. April 26.

Fig. c. Embryo sac of the Wyant, May 5, 48 long. Egg nucleus, definitive nucleus and two synergids shown.

Fig. d. Embryo sac of the Poole's Pride, May 14. 525 long. Showing great development of the sac without increase in the number of the contained nuclei. Definitive nucleus and two synergids shown.

Fig. e. Embryo sac of the Poole's Pride, May 9. Showing the synergids, egg cell and definitive nucleus.

Fig. f. Embryo sac from the second ovule of the same ovary as e. Normal, showing no signs of abortion.

Fig. g. Wyant ovule showing the embryo sac, seed coats and nucellus. May 5.

Fig. h. Embryo sac of the Poole's Pride, May 14. 105 in length.

Fig. i. Embryo sac of the Poole's Pride, May 14.

PLATE VIII.

Fig. a. An abortive ovary of the Wyant Plum, May 5, all the tissues disorganized and dead with the exception of the embryo sac itself.

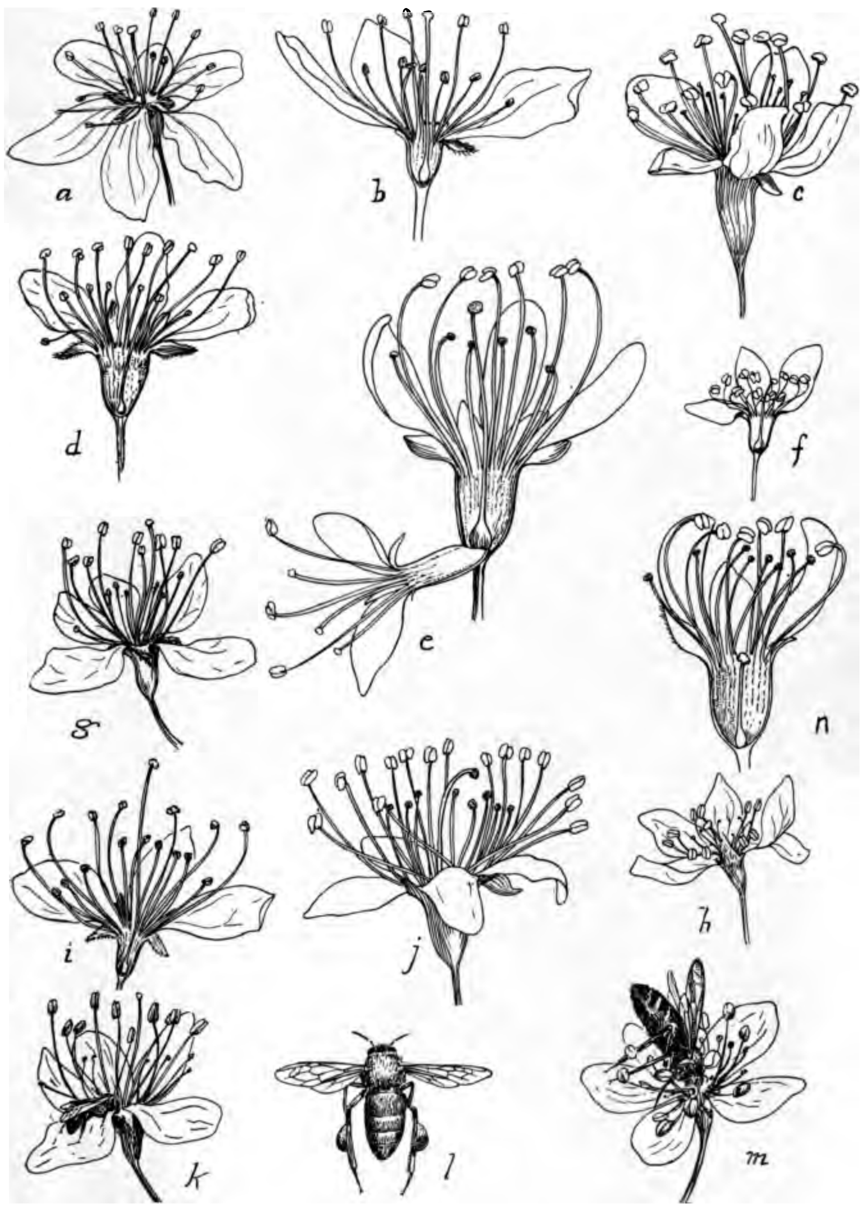
Fig. b. Abortive ovule of the Wyant showing the nuclei still vigorous and apparently normal in the embryo sac. May 5.

Fig. c. Ovary of the Wyant showing the two normal ovules previous to the abortion of one of them.

Fig. d. Longitudinal section of the plum flower in December.

Fig. e. Abortive ovule of the Wyant showing the normal embryo sac. This is an abortive ovule of a normal ovary.

Fig. f-g. Longitudinal section of the pistils of the Wyant Plum.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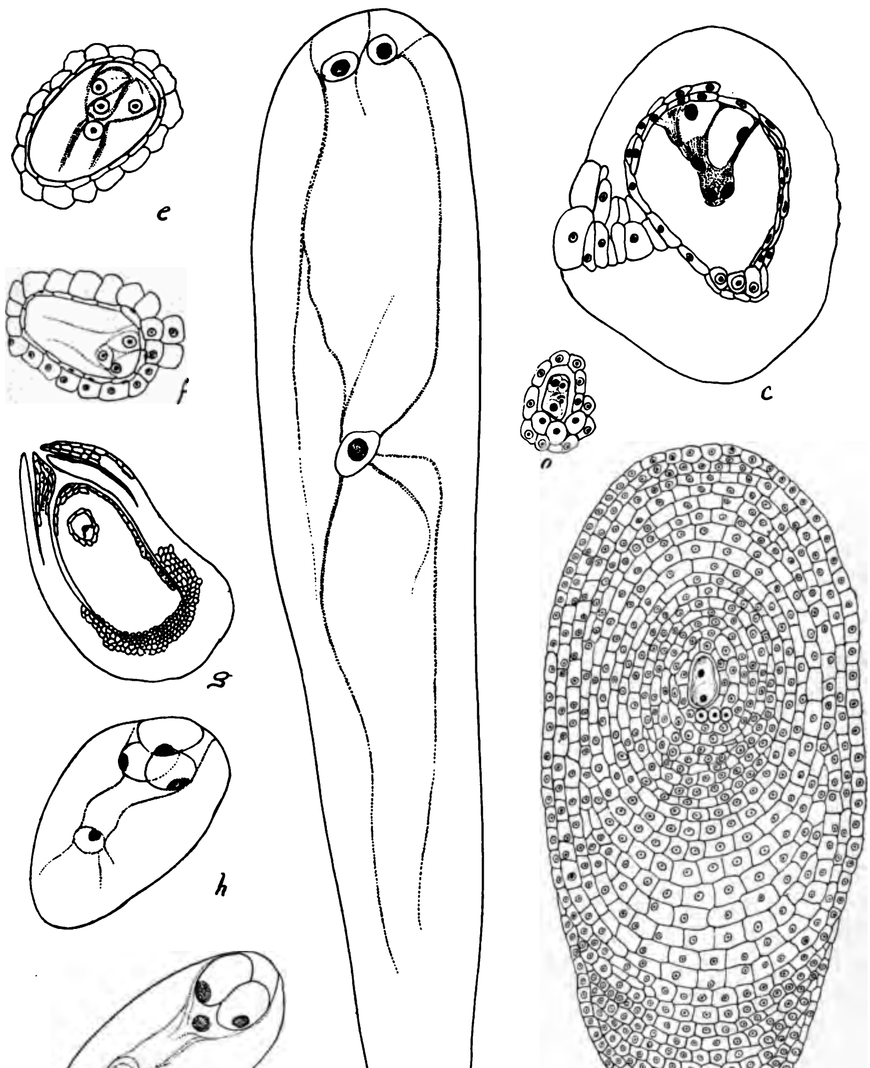
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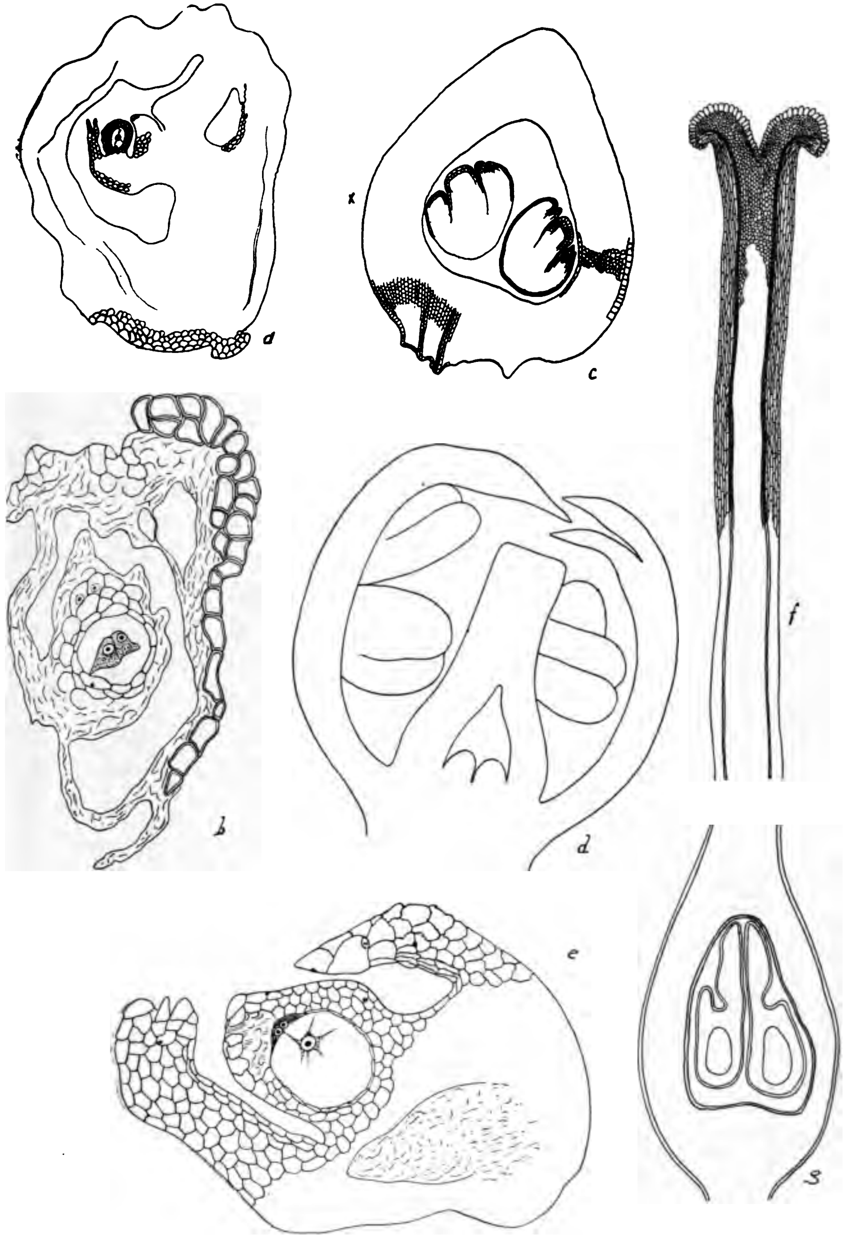
PLATE VIII.



THE SO-CALLED DORSOTRACHEALIS BRANCH OF THE SEVENTH CRANIAL NERVE IN AMPHIUMA.

BY H. W. NORRIS.

Fischer in his work on the Derotremes and Perennibranchs* describes a peculiar branch of the seventh cranial nerve in Amphiuma, distributed, according to his statement, to the hyotrachealis muscle. Kingsley in his recent paper on the cranial nerves of Amphiuma† agrees with Fischer that the nerve is one having no homologue in other Amphibians. According to him the nerve ends in the dorsotrachealis muscle. My own observations are so at variance with the views of these two writers that the following detailed account of the course of this extraordinary nerve is hereby given. Observations were made upon specimens of Amphiuma at different stages. A projection of the cranial nerves of a 130 mm. specimen was made by plotting of serial sections. (See accompanying illustration.) While the material had been neither preserved nor stained with a view to tracing nerve components, yet it gave results far better than was to be expected.

As Kingsley says, there emerge on the posterior surface of the hyomandibular trunk of the seventh cranial nerve four branches. The first is Jacobson's commissure, passing posteriorly and dorsally to anastomose with the glossopharyngeal nerve. The fourth branch, or hyomandibular proper, arises as two branches or as one that immediately divides into two. The second and third branches immedi-

*FISCHER, J. G.—Anatomische Abhandlungen uber die Perennibranchiaten und Derotremen. Hamburg, 1864.
†KINGSLEY, J. S.—The Cranial Nerves of Amphiuma. Tuft's College Studies, No. 7, 1902.

ately enter the digastric muscle. According to Kingsley the dorsal one of these breaks up into smaller branches supplying this muscle, while the ventral one passes postero-ventrally through the muscle. I find that both branches give off fibers to the muscle and pass back, uniting into one trunk near the posterior border of the muscle. In passing between the muscle fasciculi both branches become much flattened and in some places difficult to follow.

From the posterior border of the muscle the nerve rapidly ascends nearly to the dorsal border of the thymus gland, along which organ it passes posteriorly, for some distance being imbedded in the dorso-lateral border of the gland. Before reaching the thymus gland the nerve divides, the two divisions reuniting shortly after the gland is reached. In some cases a second branch is given off shortly before the first branch unites with the main nerve. This second branch has been followed to its union with the main trunk posterior to the dorsotrachealis muscle. In other cases the second division appears not to occur. After passing back nearly to the posterior border of the thymus gland the nerve enters the extreme posterior part of the dorsotrachealis muscle. It possibly gives off some fibers to the muscle, but the main trunk continues posteriorly into the connective tissue ventral to the lateral border of the longissimus dorsi muscle and between the latter and the intertransversales muscles, running approximately parallel with the ramus lateralis medius of the vagus nerve.

Posteriorly both nerves enter the longissimus dorsi muscle and continue within it to the posterior part of the body (their ultimate distribution). The facial ramus runs near the lateral border of the muscle, in some regions just at the border. A short distance anterior to the level of the posterior limbs the nerve leaves the muscle and runs just beneath the skin. I did not succeed in tracing with certainty its fibers posterior to the pelvis, but they doubtless run far back in the tail. As to the function of this nerve: As it leaves the hyomandibular

trunk some of its fibers are given off to the digastric muscle. Posteriorly it apparently distributes fibres to the dorsotrachealis muscle, but of the certainty of this I have not been able to satisfy myself. Posteriorly its relation to the dorsal series of lateral line sense-organs is such as to make it not improbable that it is concerned with the innervation of these structures. The nerve runs at the extreme lateral border of the longissimus dorsi muscle just beneath the lateral line sense-organs. Unfortunately the nature of my preparations does not permit me to trace fibers from the nerve to the sense-organs, but I find in many instances that as a sense-organ is approached the nerve bends out to the extreme border of the muscle until it lies close against the sense-organ, then after passing the sense organ sinks back to its former level. Posteriorly when the nerve leaves the muscle its fibers may be seen running along almost in direct contact with the sense-organs. The sense-organs continue nearly to the tip of the tail, but I have been unable to trace the nerve posterior to the pelvis. The nerve bears the same relation in position to the dorsal sense-organs that the ramus lateralis inferior of the vagus nerve does to the ventral series of sense-organs, only more intimate.

The suggestion of the presence of lateralis fibers in a branch of the hyomandibular trunk of the seventh cranial nerve is so contrary to accepted opinions that one may well hesitate to advance the possibility. But this entire so-called dorsotrachealis branch is an anomaly, apparently without a homologue. I have been unable to trace any connection between either the ramus superior or the ramus medius of the vagus and the lateral line organs. Neither do I find any communications between this facial branch and any branch of the vagus.

In the light of these facts this nerve evidently should not be termed the dorsotrachealis branch, but more fittingly the ramus lateralis posterior of the seventh cranial nerve.

THE VAGUS AND ANTERIOR SPINAL NERVES IN AMPHIUMA.

BY H. W. NORRIS.

After the recent excellent description of the cranial nerves in Amphiuma by Kingsley * it may seem hardly worth while to present any further account. But having the good fortune to possess some material in which the individual nerve trunks can be traced with great distinctness through the various plexuses the writer ventures to present the following brief account of the interrelationships of the vagus and anterior spinal nerves. The points wherein this paper is at variance with that of Kingsley are probably in most respects of not great importance, and possibly due to differences in the state of development of the specimens examined. This account is based on the structures studied in a specimen of 130 mm. in length.

From the glossopharyngeal-vagus ganglion I find eight nerves given off. The first and anterior of them, Jacobson's commissure (1), divides as it leaves the ganglion into two branches, one the commissure proper passing anteroventrally around the ear capsule to unite with the hyomandibular branch of the seventh cranial nerve, the other a dorso-laterally directed branch that unites with a second vagus trunk (2) at the lateral ventral border of the longissimus dorsi muscle. This off-shoot from Jacobson's commissure is probably the nerve described by Kingsley as given off from the first branchial nerve and passing to the digastric muscle. After its union with the small second vagus trunk the main part of the nerve runs anteriorly between the longissimus dorsi and anterior digastric muscles. It evidently supplies lateral line sense-

*KINGSLEY, J. S.—The Cranial Nerves of Amphiuma. Tuft's College Studies, No. 7, 1902.

organs in the occipital region. I find that it also gives off fibers to the digastric muscle. A short posterior branch seems to be distributed solely to the digastric muscle. The the small second vagus trunk seems to be the one described by Kingsley as arising from the posterior surface of the glossopharyngeal trunk and designated by him tentatively as the supratemporalis. I find that it arises from the ganglion entirely independent of the glossopharyngeal. It contributes most of the fibers of the combined nerve above mentioned. It probably corresponds to the branches supplying the sense-organs in the occipital region in Cryptobranchus as described by McGregor,* and considered by him as possibly representing the ramus supratemporalis.

A little posterior and ventral to the emergence of Jacobson's commissure from the ganglion arises a trunk (3) that soon divides into glossopharyngeal nerve proper and the first branchial nerve. This account of the first three nerve trunks differs decidedly from that given by Kingsley. According to him Jacobson's commissure and the glossopharyngeal nerve arise by a common trunk, and the first branchial nerve leaves the ganglion as a separate trunk distinct from the glossopharyngeal. I find that Jacobson's commissure and the glossopharyngeal-branchial trunk both derive a portion of their fibers from the brain through the second vagus root, but they emerge from the ganglion distinct from each other, but very close together.

The second branchial nerve (4) arises from the ganglion near its dorsal border close to the origin of the trunk termed provisionally the supratemporalis. The third branchial nerve (5) according to Kingsley arises with the second from a common trunk. I find that it leaves the lateral border of the ganglion some distance ventral to the emergence of the second branchial nerve and remains distinct from it. The ramus lateralis superior (6) arises close to the origin of the third branchial nerve, and as noticed by Kingsley ventral to the origin of the ramus lateralis medius. Leaving the ganglion the ramus latera-

*McGregor, J. H.—Preliminary Notes on the Cranial Nerves of Cryptobranchus Alleghaniensis. Journ. Compar. Neurol., Vol. VI, No. 1, 1896.

lis superior rapidly ascends to the longissimus dorsi muscle and passes back to the posterior end of the body within the dorsal portion of the muscle. The ramus lateralis medius (7) on leaving the ganglion at first turns ventrally to the level of the emergence of the remaining vagus trunk (ramus inferior) and runs parallel with it on its median border as far as the ganglion of the third spinal nerve. From this point the ramus lateralis medius ascends to the level of the longissimus dorsi muscle and in company with the ramus lateralis posterior of the seventh cranial nerve passes to the posterior region of the body, the greater part of the distance within the ventral portion of the muscle. The remaining trunk (8) given off from the vagus ganglion is by far the largest of the eight. Between the ganglia of the second and third spinal nerves it divides into three main branches. The first of these after passing ventrally and receiving a branch from the first spinal nerve divides into the ramus intestinalis and a branch running along the outer border of the first branchial artery. A second division becomes the ramus lateralis inferior supplying the ventral series of the lateral line sense-organs. A third anterior portion divides into two parts, one supplying the dorsotrachealis muscle and the other running along the inner border of the first branchial artery.

In agreement with Kingsley I find that the hypoglossal nerve arises by four roots. The two dorsal and the anterior ventral roots are very rudimentary in the specimen studied. I found no ganglion cells on the hypoglossal. They had evidently degenerated along with the atrophy of the dorsal roots. The principal hypoglossal trunk runs posteriorly in the longissimus colli muscle and finally enters into close relationship with that branch of the ramus inferior of the vagus that gives rise to the ramus intestinalis. At one point there seem to be a few fibers passing from the vagus to the hypoglossal, but I was able to trace the hypoglossal as a distinct trunk through the vagus complex to the outer border of the sternohyoid muscle.

The main trunk of the first spinal nerve runs posteriorly to the level of the posterior border of the third spinal

nerve ganglion, then turning ventrally and anteriorly divides into two branches, one of which unites with a branch of the vagus as above described, the other passes anteriorly into the connective tissue ventral to the thymus gland. The first spinal nerve does not share in the brachial plexus. The brachial plexus is formed from the main trunks of the second and third spinal nerves. I did not trace the branches of the brachial plexus to their final distribution.

EXPLANATION OF PLATE.

Projection of the VIIth., IXth. and Xth. cranial, the hypoglossal and the anterior spinal nerves of Amphiuma seen from the right side.

REFERENCE FIGURES AND LETTERS.

1. Origin of Jacobson's commissure from vagus ganglion.
2. Supratemporalis (?) nerve.
3. Glossopharyngeal—branchial trunk.
4. Second branchial nerve.
5. Third branchial nerve.
6. Ramus lateralis superior of vagus.
7. Ramus lateralis medius of vagus.
8. Ramus inferior of vagus.

aa, branches of auditory nerve.
AfBr, nerve to inner border of afferent branchial vessel.
afbr, nerve to outer border of afferent branchial vessel.
AG, Auditory-facial ganglion.
Alv, alveolaris branch of facial nerve.
Br, brachial nerve.
Brpl, brachial plexus.
Dtr, branch of vagus to dorsotrachealis muscle.
Gl, glossopharyngeal nerve trunk.
Hm, hyomandibular branch of facial nerve.
Hma, hyomandibularis accessorius branch of facial nerve.
Hy, hypoglossal nerve.
Jc, Jacobson's commissure.
Mfe, maxillaris facialis externus branch of facial nerve.
Pal, palatine branch of facial nerve.
RiX, ramus intestinalis of vagus nerve.
RlVII, ramus lateralis posterior of facial nerve.
RliX, ramus lateralis inferior of vagus nerve.
RlmX, ramus lateralis medius of vagus nerve.
RlsX, ramus lateralis superior of vagus nerve.

RtV, root of trigeminal nerve.
RtVII-VIII, auditory-facial nerve root.
RtIX-X, roots of glossopharyngeal—vagus nerves.
RtlVII, lateralis root of facial nerve.
1, 2, 3 *Sp*, first, second and third spinal nerves and ganglia.
VG, vagus ganglion.

Posterior Cranial and Anterior Spinal Nerves of Amphiuma.

A BURIED PEAT BED IN DODGE TOWNSHIP, UNION COUNTY, IOWA.

BY T. E. SAVAGE.

Union county already occupies a notable place in the annals of the Pleistocene geology of our State. Near the towns of Thayer and Afton Junction are exposed the gravel beds which first furnished the basis for the separation of the drift of the pre-Kansan age from that of the Kansan, and for the establishment of the Aftonian interglacial interval. The name of this latter age of American geology was taken from the town of Afton which is located not far from the above mentioned gravel exposures, in Union county.

Near the southeast corner of Dodge township a small, drift bordered stream crosses sections 35 and 36, and renders tribute to the Grand river a short distance east of the border of the township. About the middle of section 36 the waters of this stream have cut into the bank which borders it on the south and exposed the following succession of beds:

		FEET
4.	Fine-grained, pebbleless soil, dark gray in color at the surface, changing to yellow in the deeper portions......................	2
3.	Yellow colored drift bearing numerous pebbles and small bowlders, maximum thickness.	21
2.	Bed made up of alternating layers of brown colored vegetable matter and fine-grained, light gray sand. Greatest exposed thickness..................	6½
1.	Blue colored bowlder clay containing numerous pebbles and small bowlders of granite, greenstones, quartz and quartzite	10

It will be seen from the above section that the exposure reveals two beds of drift which are separated from each other by an accumulation of vegetable material. Since this particular area is embraced within the region whose superficial till is of Kansan age, the age of the lower or older drift, number 1 of the section, can be safely referred to that of the pre-Kansan.

The materials of this bed are dark blue in color with the exception of a zone about three feet in depth in the upper part. The superficial portion of this zone is iron-stained and is deep brown in color to a depth of two to four inches. Below this brown horizon the color changes to a light gray and this, in turn, passes with a gradual transition into the blue colored drift below. The constituents of this drift are calcareous to the very top of the bed. The clay shows nothing of the jointed structure that is a common feature of the beds of Kansan till. It contains numerous pebbles and small bowlders few of which exceed twelve inches in diameter.

The second member of the section consists of narrow layers of quite pure peaty material intercalated between layers of sand. At the very base of this bed, and immediately overlying the iron-stained horizon of number 1, there is a layer of clean, fine-grained, light colored sand about four inches in thickness. This bed of sand is succeeded by a layer of brown vegetable matter, three to four inches in depth, which in places is crowded with branches and splinters and fragments of wood. With these coarser wood-fragments are mingled masses of more or less comminuted and disintegrated remains of vegetable matter.

The entire thickness of the second member, above this basal layer of organic material, is made up of layers of fine-grained, light colored sand, which vary in thickness from two to four inches, alternating with brown colored layers of vegetable debris about equal in thickness with those of the sand. These layers of organic matter contain a surprisingly small admixture of sedimentary impurities. They are so compact that they stand out in conspicuous

Peat bed of Aftonian age. The vegetable layer exposed has a maximum thickness of 6½ feet.

relief on the face of the bluff where exposed to the influences of weathering. See plate X.

Among the plants whose remains were found in these upper vegetable layers there occur the stems and leaves and rhizoids of species of mosses which Prof. J. M. Holzinger has identified with *Hypnum* (*Camptothecium*) *nitens* (Schreb.) Schimp, and *Hypnum* (*Harpidium*,) *fluitans* Linn. Both of the above mosses are aquatic species. The former lives at present only in peat bogs and prairie swamps of more northern lands. The latter has a wider distribution. It inhabits ponds and marshes in both northern and temperate latitudes. With these mosses were also found the rootstock of a small species of fern, blades of some strap-shaped, grass-like leaves, and a fragment of a leaf resembling that of a species of populus. Numerous leaves and twigs of some cone bearing trees also occur. The leaves on these branchlets are sessile. They are jointed to short sterigmata or pedestals, and are arranged along the twig in a manner similar to those of species of Picea or Spruce. Disconnected limbs and wing-covers of beetles are occasionally encountered.

The layers of organic matter are thicker near to, and above, the middle of the member. Many of the sand layers show very thin, brown laminæ of peaty substance which indicate that even the deposition of the sand material took place very slowly.

This peat bearing member is exposed in the face of a bluff for a distance of about one hundred feet. Near the west end of the exposure a small ravine has been cut back into the hill for a distance of half a dozen rods. The vegetable horizon appears in the bank on either side of this ravine, and it is overlain with a thickness of more than twenty feet of yellow colored till.

Number 3 of the section represents a bed of Kansan drift whose lime constituent is leached from its superficial portion, and whose iron content is oxidized to a greater or less degree throughout its entire depth. There is nothing peculiar in the color or in the contents of this till as here exposed.

Number 4 is a soil mantle of fine-grained material that has been developed upon the surface of the Kansan drift during the long interval that has elapsed since the disappearance of the Kansan glacier. This pebbleless soil band and the underlying bed of Kansan drift are so familiar to all of you that they require no special discussion. Iowa geologists have encountered the drift of pre-Kansan age at various points in the State and are well acquainted with its characteristics. It is to the time of accumulation, the composition, and the manner of deposit of the materials which compose the second member, the bed of organic matter, to which I would request your consideration.

It is evident that we have here to do with an accumulation that has slowly taken place in the basin of a lake or pond. The large amount of moss in many of the vegetable layers of the member testifies to the slow rate of growth of the deposit, and to the long time during which the basin was in process of filling.

The oxidized, iron-stained band which occurs in the superficial portion of the lower drift, and which forms the floor of the basin, would indicate that the surface of the pre-Kansan drift had been exposed to the atmosphere for a long period previous to its existence as a lake bed. Also, the presence of numerous branches and fragments of wood in the lowermost layer of organic matter would be strong evidence that the deposit did not begin to accumulate immediately after the withdrawal of the pre-Kansan ice sheet. If this basin was one of the numerous depressions that were left over the surface when the pre-Kansan ice melted, the first vegetation to become established in this pool would have been species of algae, aquatic mosses, and other lowly types of water-loving plants. Not until hundreds of years after the withdrawal of the ice sheet would the drift surface become clothed with forests. Not until long centuries had elapsed after the disappearance of the glacier would there be developed conditions which would result in the accumulation of such a layer of wood fragments on the floor of a newly formed lake or pond.

The facts disclosed in this exposure seem to indicate a succession of events somewhat as follows: There is first recorded an invasion of the region by the pre-Kansan ice sheet and the deposit of the bed of bowlder clay which constitutes the first member of the section. This drift buried the preglacial forests and concealed all traces of pre-Pleistocene life. Upon the withdrawal of the ice sheet the surface of this area was subjected to the agencies of leaching and oxidation as land surfaces are today. During this time there was developed the brown colored zone in the superficial portion of this bed of drift.

After a long period, and possibly well towards the middle of the Aftonian age, some cause or causes resulted in the formation of a shallow basin over a portion of the area which formerly existed as a land surface. This new basin may have resulted from a land slip or cut off, or it may have been formed by a beaver dam or by the closing of the outlet of a stream which drained this particular region. In this forest-encircled depression waters collected. Small streams began at once to carry into it fine detritus.

In this pool water-loving mosses became established, and semi-aquatic vegetation flourished along its borders. Twigs and small branchlets that were broken from the trees during violent wind-storms came to rest in the water, and contributed their substance to the filling of the basin. During a long series of dry seasons a layer of almost pure vegetable matter would accumulate over the bottom of the bog. During a succession of seasons of greater rainfall a bed of sandy sediments would be spread over the floor. In some of these layers of sand there are thin, brown colored laminae so numerous that, in places, as many as twenty-five can be counted in the thickness of one inch. Each of these laminae probably represents the carbonaceous substance of a single season's growth of vegetation during the periods when the deposition of mechanical sediments predominated over the accumulation of vegetable matter on the floor of the marsh.

After the long continuance of such conditions as these, the pond became filled with detritus, the water was banished from the basin, and during the later portion of the Aftonian age this area was again a land surface. When the Kansan glacier moved down from the northward it carried an immense load of debris. These materials buried deeply the old Aftonian surface concealing alike forests and peat bog, the stream channels and the bordering hills. Since that time a soil mantle has been developed upon the Kansan surface, and the streams of the region have carved deeply the soft materials of the once level drift plain. In some places, as at the point above described, the cutting has been so deep as to expose deposits in which are recorded the vicissitudes of earlier geological ages.

The most of you will remember the pre-Kansan peat bed that was exposed at Oelwein, and described for the Academy a few years ago by Professor Macbride.* From the vegetable material that came from that deposit Professor Holzinger and Dr. G. N. Best have found the following species of mosses:† *Hypnum* (*Harpidium*) *fluitans* Linn., *Hypnum* (*Harpidium*) *revolvens* Swartz, and *Hypnum* (*Calliergon*) *richardsoni* Lesq. and James. Fragments of the first named species are much more plentiful in the Oelwein deposit than those of all other species combined, while in the material from Union county the remains of that species are comparatively rare. Concerning the present habitat of the two latter species Lesquereux and James state, in their mosses of North America, that *Hypnum revolvens* occurs in deep swamps from northern Ohio to Alaska, and *Hypnum richardsoni* is reported only from British America and the coast of Greenland.

The peat deposit at Oelwein is of corresponding age with that in Union county. Like that of the latter, also, its accumulation occupied a long period of time. The plant remains which occur in that northern bed bear testimony to the same facts as those in the exposure in the more southern portion of the State. It seems fair to assume

* Iowa Academy of Sciences, Vol. IV, p. 63 et seq.
† The Bryologist, November, 1903.

that the species of plants whose remains occur in these widely separated deposits afford some definite and trustworthy information regarding the climatic conditions that prevailed during the Aftonian interval.

Buried forests beds and fragments of the wood of trees which now flourish in more northern latitudes have been found at various points in Iowa. Where these trunks and wood fragments occur on the surface of a soil horizon they may represent only such trees as were growing at the close of an interglacial interval, and were overwhelmed by the oncoming of the ice. These forests may be such as were developed near the close of the interval in response to a climate that was cooled by the proximity of the slowly advancing glacier.

If the bed of vegetable material in Union county, and that at Oelwein, represent a long continued accumulation which took place neither at the very beginning nor at the very close of the Aftonian age, the species of plants whose remains are found in these deposits would testify to the general character of the Aftonian climate, unmodified by cooling winds that blew either from advancing or retreating ice masses.

The scarcity in these deposits, of fragments of our deciduous forest trees, and the presence, in abundance, of leaves and twigs and pieces of wood of cone bearing trees, such as live at present in higher latitudes, is significant. The absence in these beds of the aquatic moss species that predominate today in the lakes and pools of Iowa, and the occurrence there of species of mosses which now flourish further northward, furnish strong evidence that during the Aftonian age the climate of our state was favorable for the growth of a more boreal vegetation than at present.

The conclusion seems warranted that many of the plants which are found in the present flora of our state had no place here during that earliest interglacial interval, and that, at our latitude, the climate never became so mild and genial throughout this period as that which the region enjoys during the present age.

SOME BACTERIOLOGICAL EXAMINATIONS OF IOWA WATERS.

BY L. H. PAMMEL, R. E. BUCHANAN AND EDNA L. KING.

A good supply of water is of prime importance for every community. We are more and more beginning to appreciate and to insist on the disposal of sewage and a proper and good supply of water. It is astonishing that epidemics of typhoid fever are so common. Especially so when we know that typhoid fever is a preventable disease in large measure. It is astonishing that it is so common a disease in countries where sanitary science has attained its greatest development.

Swithinbank and Newman* in their recent exhaustive treatise on the Bacteriology of Milk give an extensive review of something like forty pages of the milk-borne outbreaks of typhoid fever. The following rather interesting statistics are collected by these authors. Dr. Cooper-Patton of Norwich has presented the following table derived from 656 cases of typhoid fever at Norwich, from the years 1895 to 1897.

Typhoid Fever Patients in Norwich (656).	Percentage of Patients.			Triennial Averages.
	1895	1896	1897	
Who drank no milk	10.0	8.0	2 0	6 6
Who drank milk raw and uncooked	25.3	24.0	29.0	26.0
Who drank milk boiled, cooked, or in tea, etc	65 0	67.5	68.0	66.8
Who used condensed milk	0.0	1.0	1 0	0.6

*SWITHINBANK AND NEWMAN.—Bacteriology of Milk. 315.

And recently Schuder,* who collected statistics of 638 epidemics of typhoid fever in different countries finds that 70.8 per cent of such epidemics are spread by drinking infected water; 17 per cent by drinking infected milk, and 3.5 per cent by other forms of food. The remainder, 9 per cent, are caused by clothes, etc., worn by typhoid patients. 29 per cent of the epidemics spread by infected milk are caused by the use of dairy utensils washed with infected water. Swithinbank and Newman have likewise collected statistics on this subject. Of the 200 epidemics studied by them they arrived at the following conclusions: But in epidemics, it has been possible to obtain the likely channel of infection between 70 and 80 typhoid epidemics.

Milk-borne typhoid epidemic probably started:	Per cent.
(a) By cases of typhoid at the farm or milk-shop	70
(b) By cases of typhoid at the farm	40
(c) By cases of typhoid at the milk-shop	30
(d) By using polluted water for dairy purposes, method of pollution unknown	20
(e) By insanitation at the farm or milk-shop and miscellaneous	10

Sedgwick† in his "Principles of Sanitary Science and Public Health" makes the following interesting comments of the spread of typhoid fever in the village of Marlborough, Mass., through skimmed milk.

"In August and September, 1894, a small epidemic of typhoid fever appeared in the city of Marlborough, Mass. Various 'theories' of the cause of the outbreak were held or suggested, and the local newspapers contained numerous letters on the subject, some alleging that the water supply was infected, some that the sewers were to blame, and some that accumulations of filth, especially dump-heaps, were responsible. The localization of the cases, however, not only disproved these theories but also suggested milk as the probable cause. It soon became evident, nevertheless, that none of the regular milkmen were involved, the cases apparently deriving their milk supplies from a variety of different sources. Eventually, however, it turned out that there existed within the city itself a creamery from which was dispatched daily a wagon loaded with skimmed milk ('separator' milk), and that nearly all of the cases of typhoid fever had been supplied with such skimmed milk either from this wagon or directly from the creamery itself. Further investigation showed that the driver of the skimmed-milk wagon was at the time of the inquiry living on the upper floor of the creamery, and just recovering from a severe attack of typhoid fever. This young man had

* SWITHINBANK AND NEWMAN.—Bacteriology of Milk. 315.
† SEDGWICK.—Principles of Sanitary Science. 275.

not only been the driver of the wagon, but had also worked over the milk, transferring it, filling cans, and otherwise making himself useful about the creamery."

The Springfield epidemic of August, 1892, was likewise attributed to the milk as a source of infection. Other cases are also here recorded.

A severe epidemic of typhoid fever occurred among the college students at Ames in the fall of 1900. A careful investigation of the well water, spring and deep well water supplying the college was made by Dr. Harriman, who had charge of the college hospital, and therefore had a good opportunity for studying all the conditions. He concluded that the milk supplying the college dining room was the source of infection.*

The general conclusions reached by the writer in a paper† were as follows: It may be stated that so far as the analyses show the college water supply may be considered excellent. It is true that in a number of instances more organisms were found than at other times, but an examination made from time to time shows that the number is not unusually large, and on the whole that we may consider our water supply practically pure, and I should also state that the water from the spring supply is unusually good. We should bear in mind that the failure to find the typhoid fever bacillus in the water supply of the Briley well is not at all surprising. It is a well known fact that the saprophytic species grow so readily in the nutrient media that the typhoid fever bacillus has not the same chance to grow. The same may also be said with reference to milk, only here we are dealing with such a large number of species that it would be a mere accident to discover the organism. As stated before, it seems to me to be reasonable that the milk formed a favorable medium for the growth of the typhoid organism, and be it especially remembered that Mr. Briley, from his own testimony, failed to wash the cans with boiling water as should have been done. The milk cans could easily have been

* The Jr. of the Am. Med. Assoc. 38: 511. 1902.
† Proc. Ia. Acad. Sci. Vol. 8. 274.

contaminated, and the failure on his part to wash the cans, it seems to me, made it not only possible but probable that these germs propagated in the milk dippings. A comparison of water of the Briley well and the college effluent shows that the Briley well had a greater amount of contamination than the college effluent from the sewage filter beds.

The general conclusion seems evident that the flies transferred the organisms from the dejecta which were not sufficiently sterilized over to the *milk, and thus the germs* found their way into the milk cans. The pails used to carry the milk were simply rinsed with cold water and dumped out near the well. The typhoid bacilli no doubt developed rapidly in the milk and thus might have found their way into the well.

All bacteriologists recognize the importance of making both bacteriological and chemical analyses of water to determine whether it is suitable for sanitary purposes. Many of our Iowa waters have been examined from a sanitary standpoint. In most of our smaller towns the city water is derived from deep wells, while the larger cities like Des Moines, Cedar Rapids, Waterloo, Burlington, Davenport, Dubuque, Iowa City, and Council Bluffs derive their water from streams.

The sanitary analysis of water from a bacteriological standpoint involves a great many difficulties. Among these we may mention the interpretation of results obtained in these analyses. The earlier bacteriological results seemed to indicate the general presence of the bacillus of typhoid fever in suspected water. No less than half a hundred of these positive determinations are on record until bacteriologists began to suspect that the finding of the bacillus of typhoid fever by these observers was an error. It appears, however, from some very careful studies made by Kübler and Neufeld* and a few others that the *B. typhosus* has been found in water. Sedgwick and Winslow† found that of the typhoid bacillus in ice or cool water over 40 per cent will perish in three hours

* ZEITSCH.-f. Hygiene. 31: 13?.
† Mem. of the Am. Acad. Arts and Sci. 12: 467.

and 98 per cent and upwards in two weeks. It does not seem probable that this organism will retain its vitality for a great while in ordinary water. It certainly does not propagate. Shortly after the discovery of the agglutinating property of *B. typhosus* by Widal renewed efforts were made to detect the typhoid bacillus in water and on the strength of these tests several French investigators found the bacillus everywhere, in water, in soil, and the faeces of healthy individuals.* A German investigator relying on this test found the water in certain cisterns infected and an Englishman, Hankin,† found it common in the soil and other places. Further investigation, however, revealed the fact that the colon bacillus is also agglutinated by the typhoid serum. It, therefore, appears that so far as these tests are concerned that we still need a great deal of information on the subject, that we are still somewhat uncertain on some points.

Dr. Vaughan ‡ says, "I have never found in drinking water a germ that responded to the Wi ·:i test."

For a valuable paper on bacteriological analysis of water the paper by Winslow ‖ should be consulted.

The English have used phenolated media.§ "It was at one time thought that the addition of .2 per cent carbolic acid to the ordinary media inhibited the growth of all bacteria but the typhoid bacillus. It has been found, however, that the growth of the *B. coli* is also unaffected by such a medium, though it prevents the growth of most putrefactive organisms which liquify gelatin." And Hankin, of the British Army Medical Corps in India, uses Parietti solution as follows: Four per cent of hydrochloric five per cent carbolic acid or phenol. His method is as follows: "He adds portions of the water to be tested to tubes containing successively increasing proportions of Parietti solution. The tubes at the bottom of the series, in which the acid is not too strong, become turbid, and

* Ann. de l' Inst. Pasteur. 11: 55.
† Centr. Bakt. 26: 554.
‡ The Jr. of the Am. Med. Ass. 42: 941.
‖ WINSLOW, C. E. A.—Bacteriological Analysis of Water and Its Interpretation. New Eng. Water Works Assoc. 15: 470.
§ MUIR & RITCHIE.—Manual of Bacteriology. 380.

instead of taking the tube with the highest amount of acid in which growth occurs (which would probably contain only *Bacilli coli*), Hankin* takes the one just below for the inoculation of a new series. Finally pure cultures are isolated on the agar plate and tested by various subcultures."

In a bacteriological examination of waters it is essential to carry out the rules laid down by the American Public Health Association and those adopted by the Massachusetts State Board of Health, and the methods used in the laboratory of the Boston Institute of Technology. The methods consist essentially in making quantitative analyses, and first of all it is important that all media should be perfectly sterilized for the least amount of error in this respect will make the results of no value. In spite of the fact that the greatest care is used in the making of media it sometimes happens that some of the tubes become infected in some way. As to the use of media, it is generally admitted that gelatin, agar agar, and litmus lactose agar and the fermentation tube with dextrose are important in obtaining reliable results.

Quite recently Dr. Vaughan† has given the results of an examination of water supplies from various sources under the head of "Some Toxicogenic Germs Found in Drinking Water." He uses for his work agar plates, one grown at the room temperature, the other at 38 degrees C. The toxicogenic bacteria have their optimum growth at 38 degrees C., while many of the saprophytic water bacteria grow at lower temperatures. The pathogenic bacteria crowd out the saprophytic at a higher temperature. The colonies are counted at the expiration of twenty-four, forty-eight and seventy-two hours. Bouillon tubes are inoculated at the same time with like amounts of water. These tubes are kept in the incubator for twenty-four hours at from 38 degrees to 40 degrees C. The temperature is not allowed to fall below 38 degrees C. If bacteria do not develop at this temperature it is regarded as safe. If bacteria are

*HANKIN, E. H.—Centr. f. Bakt. 26: 554.
† Jr. of the American Medical Assoc. 42: 635.

found in the tubes in the incubator from 1 to 2 c. c. of the beef tea bouillon is injected intra-abdominally into white rats or guinea pigs. Two animals are inoculated. If the animals do not die it is regarded as safe. If animals die agar cultures are made from the heart's blood. The plates are incubated at the temperature of blood. The colonies are carefully studied. The *Bacillus venosus* seems to be the germ which was found in wells suspected to have caused the infection of typhoid fever.

The chemical composition of the medium as has been shown by Messrs Winslow, Fuller, Sedgwick and Prescott* is important.

Mr. Winslow especially recommends agar agar, gelatin, glycerin agar, and the litmus lactose agar.

On the importance of the use of this medium Winslow and Nibecker† give the following rather interesting table:

Sources of Water.	Average No. of Colonies per c. c.	
	Gelatin20°	Wurtz-Agar 37.5°
Well, spring	1,664	28
Reservoirs	153	43
Ponds	296	95
Taps	242	24
Streams	273	101

In a general average of 259 samples of water studied by Winslow and Nibecker they give the following interesting summary of their work:

*Jr. New Eng. Water Wks. Assoc. Vol. 15: 462. Also Technological Quarterly 16: 228.

†WINSLOW, C. A. E. and NIBECKER, C. P.—Techn. Quar. Vol. 16: No. 3. Sept. 1903.

TABLE I.

EXAMINATION OF 259 SAMPLES OF WATER FROM APPARENTLY UNPOLLUTED SOURCES.

Source of Samples.	Number of Samples.	Gelatin Plates.				Litmus-Lactose-Agar Plates.					Dextrose-Broth Tubes.			
		Number of plates.	Maximum number of colonies.	Minimum number of colonies.	Average number of colonies.	Number of plates.	Maximum number of colonies.	Minimum number of colonies.	Average number of colonies.	Plates showing red colonies.	Number of tubes.	Number of tubes with gas.	Number of tubes with gas. 1-0.	Number of tubes with gas. 2-1.
Cambridge supply (tap)	5	10	240	20	94	8	15	2	11	0	15	0	0	0
Wakefield and Stoneham supply (tap)	7	14	150	20	59	13	12	2	6	0	21	0	0	0
Lynn supply (tap)	6	12	20	0	16	12	6	1	3	0	18	0	0	0
Brookline supply (tap)	1	2	All	liquefi	ed.	2	21	15	18	2	3	0	0	0
Plymouth supply (tap)	6	12	70	10	35	12	6	0	2	0	18	0	0	0
Peabody supply (tap)	3	6	261	30	141	5	36	1	21	0	9	2	2	2
Dedham supply (tap)	6	12	13,500	0	3,717	11	3	0	1	0	18	0	0	0
Newburyport supply (tap)	6	12	100	10	36	12	14	2	9	0	18	0	0	0
Salem supply (tap)	5	10	267	200	232	10	23	10	14	0	15	0	0	0
Taunton supply (tap)	4	7	41	10	13	8	5	0	2	0	12	0	0	0
Sharon (well) (tap)	3	6	845	630	738	6	74	30	46	2	9	3	0	3
Medford supply (tap)	5	10	1,250	240	524	10	16	3	8	0	15	0	0	0
Milton supply (tap)	2	4	5,000	4,200	4,700	4	0	0	0	0	6	0	0	0
Westerly, R. I. supply (tap)	1	2	All	liquefi	ed.	2	18	12	12	0	3	0	0	0
Brooks	61	122	1,010	30	223	221	83	0	7	0	183	13	13	0
Driven wells	15	30	54	0	18	30	5	0	1	0	45	0	0	0
Springs	52	64	1,270	20	294	64	13	0	2	0	95	13	13	0
Ponds, fed by brooks	15	30	340	100	167	30	24	0	9	0	45	1	1	0
Melted snow	1	2	All	liquefi	ed.	2	5	3	4	0	3	0	0	0
Pools in fields	22	44	760	100	365	44	95	2	31	0	66	2	2	0
Pools in woods	22	44	580	10	181	43	14	0	3	0	65	0	0	0
Roadside pools	10	20	9,000	410	811	20	10	0	4	0	30	2	2	0
Stream, Blue Hill Reservation	1	2	All	liquefi	ed.	2	0	0	0	0	3	0	0	0
Flow from rocks	2	4	60	30	47	4	2	0	0	0	6	0	0	0
Ponds, fed by springs	6	12	420	60	188	12	5	0	2	0	18	0	0	0
Drains from manured pastures	1	2	1,270	1,200	1,235	2	28	26	27	0	3	0	0	0
Swamps	3	6	310	240	269	6	10	0	6	0	9	5	5	0
Rain water, after 12 hours' heavy fall	7	14	All	liquefi	ed.	14	6	0	2	0	21	0	0	0
Shallow well in Lynn woods	1	2	20	10	15	2	1	1	1	0	3	0	0	0
Totals	259	517	....	....	....	511		......	......	4	775	41	38	3

They concluded as follows: "If we consider the results of this examination of the litmus-lactose agar plate it becomes apparent that organisms capable of growth at the body temperature are not numerous in unpolluted waters; acid formers are practically absent."

In addition to these media we have used in our water investigation of the well supplies ordinary litmus agar and litmus gelatin, dextrose agar. None of these media have, however, been very satisfactory. The litmus agar and gelatin, and especially the dextrose contained as a rule less organisms than the gelatin.

In order to get accurate data on water supplies especially from a bacteriological standpoint the bacteriologist should at least insist on collecting the samples himself, and under conditions which will guarantee a perfect sample. They should be plated as soon as possible after the water is collected. We can not insist too strongly on the statement made by C. E. A. Winslow* that "The extreme delicacy of the test renders imperative the utmost care in the technique of bacteriological analysis; for a speck of dust, a delay of a few hours, or a mistake in the preparation of the nutrient gelatin, may introduce an error in excess of the normal difference between the purest and the most polluted drinking-waters. First, in the collection of the sample, it must be certain that the small portion taken represents fairly the whole body of water from which it is drawn. The first water flowing from the tap or a pump must be rejected, as it may have acquired impurities from the mouth of the faucet or of the spout. On the other hand, water which has stood all night in the service pipes of a house will be lower in bacteria than the supply from which it is derived. In a lake or pond the surface scum and bottom sediment must be equally avoided."

Bacteria begin to multiply more after the sample is collected. All of our waters contain sufficient nutrient material to cause such multiplication.

*WINSLOW, C. E. A. Jr. New Eng. Waterworks Assoc. 15: 460.

One of us called attention to this fact some years ago,* but as early as 1879, Miquel,† found that the number of organisms increased very perceptibly after it had been kept a certain length of time. The following quotation from Frankland‡ indicates a final decline. "Miquel has extended these observations in an interesting manner by keeping a bottle of river Seine water shut up for nine years, and whilst at the time of collection 4,800 bacteria per c.c. were found, at the end of the nine years there were only 220 discoverable. Again, a sample of Vanne water, containing at the time of collection 66 organisms per c.c., at the end of ten years was found to be absolutely sterile."

Cramer§ gives the following increase:

Hours and days during which the water was preserved.	Number of micro-organisms in 1 c.c. of water.
0 hours	143
24 hours	12,457
3 days	328,543
8 days	233,452
17 days	17,436
80 days	2,500

The bacteriologist is often asked to examine water that is shipped from long distances. He is asked to make a report on the sanitary conditions of the water. This water is frequently collected in ordinary bottles, simply rinsed. Of course, it goes without saying that such analyses can not be reliable. A case in point of the undoubted multiplication of bacteria may be found in spring water from Canton, northeastern Iowa. The spring water is said to be unusually good, the number of bacteria found in the water was very large, the average in different media was 22,000 per c.c.

Sometimes water is packed in ice and sent for study. This is not always a desirable method for shipping water. Thus, Jordan‖ found that three samples of river water packed in ice for 48 hours, fell off from 535,000 to 54,500; from 412,-

* PAMMEL, L. H.—Proc. Ia. Accd. Sci. 1: 493. 1893.
† MIQUEL, MANUEL.—Pratique d'analyse bacteriologique des aux. Paris, 1891. p. 12.
‡ FRANKLAND.—Micro-organisms of Water. 219.
§ CRAMER.—Die Wasserversorgung von Zürich und ihr Zusammenhang mit der Typhusepideme des Jahres 1884. Zürich, 1885: 91.
‖ WINSLOW, C. E. A.—Jr. New Eng. Water Works Assoc. XV: 461.

000 to 50,500, and from 329,000 to 73,500, respectively. It is thus evident that the bacteriologist must not only see to the collecting of his own samples, but must be intimately acquainted with their history until they reach his laboratory.

A further precaution that should be taken in making an analysis is the proper plating and the amount of dilution. We have found in ordinary practice of wells that $\frac{1}{10}$ of a c.c. of water is sufficient. The melted agar is poured out on the plate and the water is added to it. Then by gently tilting the plate backward and forward an even distribution of the germs is obtained. The same method is used in gelatin plates. The gelatin plates harden less rapidly and hence a better distribution will be obtained than on agar, care, of course, being used when the plates are poured that there is no dust in the room, that the ends of the tubes shall be run through flames so that no germs will adhere when the agar is poured into the Petri dishes. For river water, especially if strongly polluted, it is necessary to dilute about ten times although this may have to vary. It is not advisable to have the plate covered with colonies as the different colonies are inimical to their development.

The following is the result of our analyses of wells supplying the college boarding houses. The shallow wells are marked S.

TABLE II.

BACTERIOLOGICAL TEST OF WELL WATER. I. S. C.

Owner.	Date.	Depth of well.	Temperature.	1st.	Media Used.								Gas.
					2nd Pumping.								
				Agar.	Agar.	Lit. Agr.	Acid.	Gel.	Liquef.	Lit. Gel.	Acid.	Gluc. Ag.	
Baughman, John.	Jan. 7, 1904	..	8 °C.	20	20 10	110 100	0 0	180 120	60 20	120 50	0 0	20 0	None.
Baughman, John.	March 5, 1904	....	....	....	50 10	20 20	0 0	10 0	0 0	30 0	10 0	80 30	None.
Briley, O. A. 1 .	Jan. 15, 1904	110	9¼ °C.	710	40 100	10 20	0 0	0 30	0 0	0 0	0 0	50 60	None.
Briley, O. A. 1 ..	....	....	....	....	....	....	. ..	.... ..	.. ..	....	.. ..	.... ..	......
Briley, O. A. 2 ..	Jan. 5, 1904	40	8 °C.	30	160 800	120 20	0 0	200 190	40 30	220 180	0 0	40 0	CO_2 22%. H 88%.
Briley, O. A 2 ..	March 11, 1904	....	7¼ °C.	1500	1100 970	410 330	0 0	0 0	0 0	0 50	0 0	20 30	Abundant
Cattell, M. C .	Jan. 7, 1904	60	9 °C.	50	40 30	70 0	0 0	30 10	0 10	20 30	0 0	1000	Slight.
Cattell, M. C	March 5, 1904	....	....	....	0 0	60 50	0 0	0 0	0 0	30 80	0 0	0 0	None.
Caughey	Jan. 5, 1904	60	7¾ °C.	20	20 0	10 5	0 0	40 50	10 25	60 40	0 0	0 20	None.
Caughey	March 11, 1904	....	10 °C.	....	70 80	70 20	0 0	30 0	10 0	50 110	10 0	90 210	None.
Cole, A. W.......	Jan. 7, 1904	65	8¾ °C.	....	80 50	10 0	0 0	30 70	0 0	40 30	0 0	40 70	Slight.
Cole, A. W......	March 5, 1904	....	....	..	0 20	30 0	10 0	10 0	10 0	20 0	0 0	20 10	None.

TABLE III.

BACTERIOLOGICAL TEST OF WELL WATER. I. S. C.

Owner.	Date.	Depth of we l	Temperature.	1st.	Media Used.								Gas.
					2nd Pumping.								
				Agar.	Agar.	Lit. Agr.	Acid.	Gel.	Liquef.	Lit. Gel.	Acid	Gluc. Ag.	
*Connell, R. D.	Jan. 3, 1904	114	9½ °C.	500	14350 1680	60 80	0 0	14700 31500	0 0	75 23100	0 0	33600 14750	None.
Connell, R. D..	Mar. 11, 190	...	13½ °C.	21000	21000 21000	0 28000	0 0	35000 28000	0 0	40	0 0	2100 4200	None.
Dixon, F. N....	Jan. 13, 1904	50	9 °C.	750	36 20	60 0	0 0	100 80	70 80	20 90	0 0	30 0	None.
Dixon, F. N....	Mar. 11, 1904	...	6 °C.	... .	1000 500	520 0	0 0	2000 200	1000 0	6300 6300	0 0	4200 0	None.
Eldridge, Mrs..	Jan. 6, 1904	...	....	20	10 10	10 20	0 0	0 0	0 0	30 20	0 0	30 40	None.
Eldridge, Mrs..	Mar. 5, 1904	...	....	.....	20 20	40	0 0	100 20	0 0	0 0	0 0	0 10	None.
Foster, Clay....	Jan. 6, 1904	Shallow.		40	100 10	30 400	0 0	80 0	20 0	20 30	0 0	20 0	None.
Foster, Clay....	Mar. 5, 1904	...	....	.....	20 10	10 20	0 0	20 10	10 0	10 0	0 0	0 20	None.
Freed, O. D ...	Jan. 7, 1904	50	....	670	110 .	30	0 0	210 150	50 100	150 50	0 2	30 300	None.
Gray	Jan. 7, 1904	...	....	120	50 80	50 250	0 60	All All	liq liq	uifie uifie	d d	10 20	In 3 of 5 tubes.
Gray	....	..	10 °C.	100	120 50	50 90	0 0	0 30	350 500	350 500	0 .	0 90	In 1 of 3 tubes.

* Colonial Club.

TABLE IV.

BACTERIOLOGICAL TEST OF WELL WATER. I. S. C.

AVERAGES OF ALL PLATES.

Owner.	Depth of well.	Distance From		Average Number of Bacteria per C. C.							
				1st Pouring.				2nd Pouring.			
		Barn.	Cess pool.	Date.	Temp.	1st pump.	2nd pump.	Date.	Temp.	1st pump.	2nd pump.
Baughman, John	...	...	40	Jan. 7, 1904	8 °C	20	73.0	Mar. 5, 1904	....	.....	25
Briley, O. A. 1..	110	100	...	Jan. 5, 1904	$9\frac{1}{4}$ °C.	110	81.0	....	....	.	.....
Briley, O. A. 2..	40	20	300	Jan. 5, 1904	8 °C.	30	193.0	Mar. 11, 1904	$7\frac{1}{4}$ °C.	1500	291
Cattell, M. C....	60	...	...	Jan. 7, 1904	9 °C.	50	123.0	Mar. 5, 1904	......	...	22
Caughey	60	.	100	Jan. 5, 1904	$7\frac{3}{4}$ °C.	20	25.0	Mar. 11, 1904	10 °C.	....	73
Cole, A. W	65	...	100	Jan. 7, 1904	$8\frac{3}{4}$ °C	..	42.0	Mar. 5, 1904	....	.	11
Connell, R. D. ..	114	...	100	Jan. 8, 1904	$9\frac{1}{2}$ °C.	500	18329.5	Mar. 11, 1904	$15\frac{1}{2}$ °C.	21000	1493[illegible]
Dixon, F. N.....	50	5	80	Jan. 13, 1904	9 °C.	750	43.6	Mar. 11, 1904	6 °C.	.....	2102
Eldridge, Mrs...	...	150	50	Jan. 6, 1904	....	20	17.0	Mar. 5, 1904	....	....	2[illegible]
Foster, Clay.....	...	75	...	Jan. 6, 1904	....	40	69.0	Mar. 5, 1904	......	.....	12
Freed, O. D.	58	.	100	Jan. 7, 1904	....	670	108.0	....	....	.....	.....
Gray	...	25	200	Jan. 7, 1904	....	120	98.0	....	10 °C.	100	128

TABLE V.

BACTERIOLOGICAL TEST OF WELL WATER. I. S. C.

AVERAGE OF ALL AGAR PLATES.

Name.	Depth.	No.	Name.	Depth.	No.	Name.	Depth.	No.
Baughman, John	.....	23	Hodgdson .	Shallow	347	Minert	94	66
Briley, O. A. 1..	110	87	Holmes, M. L.	Deep	226	Munn, H. J ...	65	53
Briley, O. A. 2..	S. 40	1140	Hook, W. A...	150	56	Otis, Mrs.	80	22
Cattell, M. C....	60	80	Hunt, M.......	10	67	Overholser, I...	S. 57	340
Caughey	60	47	Johnson	155	10	Parker, east ..	107	37
Cole, A W......	65	38	Kibby..........	Shallow	263	Parker, west...	87	43
Connell, R D. .	114	13288	Long, W.......	100	20	Parsons	S. 30	25
Dixon, F. W....	S. 50	564	Macburney ..	85	152	Poage, Mrs. H.	83	20
Eldridge, Mrs...	50	16	Madson, N ...	S. 57	46	Ross, Mrs.	100	...
Foster, Clay....	Shallow	36	McCune, H	Deep	28	Rubel, E. S.....	110	185
Freed, O. D. ...	S. 58	390	McDaniel	118	158	Scroggie, O. R.	Deep	47
Gray	Deep	87	Miller House ..	110	50	Stalker, Dr.....	75	172
Greer, W. K ..	74	26	Miller Store...	....	86	Story, N. F	110	50
Hanson	100	185	Miller, R. J. ..	60	860	Tuttle, E. C ..	120	182
Hill, L.	50	120	Miller, J B. ..	110	160	Walters, Mrs...	75	37

TABLE VI.

BACTERIOLOGICAL TEST OF WELLS AND WATER SUPPLIES, GRINNELL, AND DES MOINES, IOWA.

Locality.	Source of Water.	1st Pumping.		2nd Pumping.	
		1st Agar.	2nd Agar.	1st Agar.	2nd Agar.
Grinnell ..	Bliss, Mr., private well	50	1400	80	1900
Grinnell ..	Kingston, Mr., private well	160	....	3500	.. ....
Grinnell .	Jenkins, Mr., private well	100	150	3500	3500
Grinnell ..	Tap water, collected 1 min., 5 min. and 10 min.	100	80	60	....
Grinnell ..	Cistern, city supply	10	10	....	....
Grinnell ..	Effluent of cistern, city supply	100	1000	.. ..	.. ....
Grinnell ..	Soft water for boilers, city main	540	270	....	....
Grinnell ..	Inflow, city cistern	0	0	....	.. ....
Des Moines	Shallow well, Walnut street	400	7500	....	....
Des Moines	Artesian well, 360 feet deep	400	50	....	....

TABLE VII.

BACTERIOLOGICAL TEST OF WATER FROM COLLEGE CREEK, I. S. C.

Date.	Point.	1st Agar.	2nd Agar.	1st Glu. Ag.	2nd Glu. Ag.	1st Lit. Ag.	2nd Lit. Ag.	1st Gelatin.	2nd Gelatin.	1st Lit. Gel.	2nd Lit. Gel.
*Jan. 15, 1904	Above the inflow of Colonial House sewage. I.	1100	3500	140	.....	350	50	70	60	0	0
*Jan. 15, 1904	Below the Colonial House. II.	510	1320	670	620	160	110	10	0	10	0
*Jan. 15, 1904	By the President's House. III.	80	100	220	3200	55800	70000	10	0	0	0
*Jan. 15, 1904	Below the College sewer. IV.	4900	3500	1460	1220	2330	6300	10	0	0	0
†Mar. 30, 1904	Above the inflow of Colonial House sewage. I.	46000	....	80500	54000	72000	51000	102000	92000	62000	9000
†Mar. 30, 1904	Below the Colonial House. II	.....	....	30000	52000	24000	91000	84000	90000	105000	86000
†Mar. 30, 1904	By the President's House. III.	.....	....	.....	.....	70000	80000	90000	80000	81000	70000
†Mar. 30, 1904	Below the College sewer. IV.	.....	....	25000	45000	22000	25000	90000	92000	10000	45000

*Ice. † Flood.

TABLE VIII.

BACTERIOLOGICAL TESTS OF VARIOUS IOWA RIVER AND SPRING WATERS.

River.	Locality.	Plated by	Date.		Number Bacteria per C. C. on Agar.					
Skunk	Story City	E. V. Larson	Feb. 27, 1904	Sample each hour for six hours	8200	5000	10820	3080	10030	19200
Skunk	Story City	E. V. Larson	Feb. 27, 1904	Sample each hour for six hours	8240	2040	6200	1560	......	9080
Skunk	Story City	E. V. Larson	March 26, 1904	Sample each hour for three hours	11410	16590	12040	.	......	....
Skunk	Story City	E. V. Larson	March 26, 1904	Sample each hour for three hours	10220	......	6650	.	...	
					Hour.	Temp.	Bacteria 1″.	Bacteria 2″.		
Des Moines	Boone	J. W. Jordan	Feb. 18, 1904	Sample each hour for six hours	10 A. M.	0°C.	40	....		
Des Moines	Boone	J. W. Jordan	Feb. 18, 1904	Sample each hour for six hours	11 A. M.	0°C.	1000	2750		
Des Moines	Boone	J. W. Jordan	Feb. 18, 1904	Sample each hour for six hours	12 M.	0°C.	500	800		
Des Moines	Boone	J. W. Jordan	Feb. 18, 1904	Sample each hour for six hours	1 P. M.	1°C.	250	1000		
Des Moines	Boone	J. W. Jordan	Feb. 18, 1904	Sample each hour for six hours	2 P. M.	1°C.	600	....		
Des Moines	Boone	J. W. Jordan	Feb. 18, 1904	Sample each hour for six hours	3 P. M.	1°C.	250	500		
					Above Sewer		Below Sewer			
					1″.	2″.	1″.	2″.		
Des Moines	Des Moines	H. S. Fawcett	March 19, 1904	....	1400	4200	87500	77700		
					Agar.	Lit. Lac. Agar.	Gel.			
Iowa	Marshalltown	L. H. Pammel	April 5, 1904	Back of Old Soldiers' Home	8500	800				
Mississippi	Davenport	L. H. Pammel	April 13, 1904	Foot of Brady street	18900	5600				
Mississippi	Davenport	L. H. Pammel	April 13, 1904	Near waterworks	8400	....				
Mississippi	Davenport	L. H. Pammel	April 13, 1904	Near waterworks	8900	....				
Mississippi	Davenport	L. H. Pammel	April 13, 1904	Near waterworks	1 000	5600				
Maple	Carroll	L. H. Pammel	May 28, 1904	....	400	300	700			

SPRING WATERS.

Spring	Locality.	Plated by	Date.	No.	Date.	No.	Date.	No.	Remarks.
Wayne's	Boone	Miss Rowe	Oct. 19, 1903	600	Dec. 30, 1903	440	Jan. 10, 1904	490	....
Williams'	Boone	Miss Rowe	Oct. 10, 1903	1400	Jan. 17, 1903	3300	March 13, 1904	5800	Surrounded by herbage.
College	Ames	Miss Rowe	Oct. 15, 1903	150	Oct. 21, 1903	160	Oct. 29, 1903	140	Brick cased
College	Ames	Miss Rowe	Jan. 5, 1904	120	Feb. 19, 1904	120	March 8, '904	150	Brick cased.
Farm	Ames	Miss Rowe	Oct. 14, 1903	3100	Feb 22, 1904	2400	April 4, 1904	3800	Surrounded by herbage.

The conviction has grown on us that none of the Iowa wells are absolutely free from bacteria. Generally speaking, the deep wells contain less organisms than the shallow. Prescott and Winslow* conclude that "it is plain that water absolutely free from bacteria is not ordinarily obtained from any source and that even deep wells contain quite appreciable numbers." They find that the bacteria from deep wells show a slow development at room temperature, "the entire absence of liquefying colonies and the abundance of chromogenic bacteria." In our investigation two types of wells have been examined. (1) The shallow which are usually bricked or tiled. They rest on a blue clay. (2) Tubular wells varying in depth from 60 to over 100 feet. In the vicinity of Ames they have gone through the Wisconsin drift. The plates were not incubated but they were plated in a covered case and counted in 48, 72 and 120 hours. Duplicate plates were poured in each case. The older the well the greater are the number of bacteria. It is also evident that there are many interesting problems in connection with a study of our water supplies.

*Elements of Water Bacteriology. 18.

Fig. a. A pond and well in Marshalltown, showing the location of the well close by the pond. Bad surface water.

Fig. b. A dairyman's premises in Marshall County, Iowa, with dilapidated barns, poor well and general untidy conditions. Near Marshalltown, Iowa.

Fig. a A Colonial club-house well. Well with excellent surroundings, neat and clean, on a hill; the well over 100 feet deep and yet containing a large number of organisms. Probably an underground channel occurs, or perhaps there is a leak in the pipes.

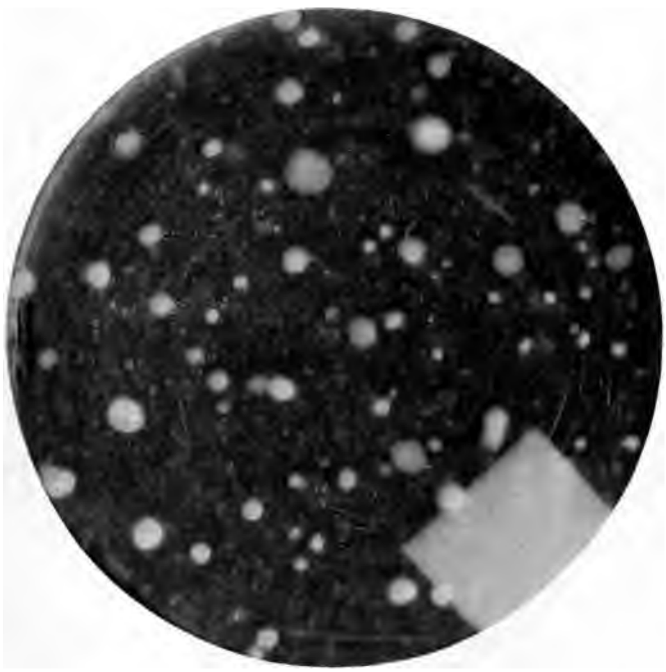


Fig. b. Organisms.

g a. Pla'e showing the development of colonies taken from Briley shallow well. Containing but few organisms.

. b. Taken from shallow creek receiving sewage. Three types of colonies are shown; the small colonies very numerous.

SOME FEATURES IN THE ANALYSIS OF DOLOMITE ROCK.

BY NICHOLAS KNIGHT.

The purpose of this work was to compare different methods of determining silica in dolomite, and also to ascertain the amount of magnesium oxalate that will precipitate with calcium oxalate in connection with the analysis of dolomite rock by different students. These rocks abound in Iowa and in many other portions of the United States. The specimens under examination were variable mixtures of calcium and magnesium carbonates, with silica, ferric oxide and aluminum oxide. All were obtained from the Mount Vernon quarry and belonged to the Niagara period of geologic history.

At first a complete analysis of each specimen was made. Miss Grace Bradshaw determined the silica by two different methods to see how the results might agree.

1. A gram of the fine powder was placed in a small beaker, and, covered with a watch glass, it was dissolved in pure, dilute hydrochloric acid, by gently heating to the boiling point. The insoluble residue consisting of silica was filtered and the amount determined.

2. A gram of the substance was placed in a porcelain evaporating dish, and while covered with a watch glass, dilute hydrochloric acid was added. It was warmed on the water bath until there was no more evolution of gas.

The contents of the watch glass were rinsed into the dish and evaporation continued until crystals began to appear. Then as the drying continued it was stirred with a glass rod until a fine dry powder resulted. This was moistened with a few drops of concentrated hydrochloric acid and then about 20 c.c. dilute hydrochloric acid and the same quantity of water were added. The precipitate was filtered and determined as silica.

Analyses by the first method of the same specimen gave 0.75 per cent and 0.76 per cent silica, and by the second gave 0.78 per cent. As the results were similar, and as the determinations could be made much more easily and quickly by the first method, it was the one usually practiced.

About two grams of ammonium chloride were added to the filtrate from the silica, and at the boiling temperature it was treated with a small excess of ammonia to precipitate the iron and alumina. The filtrate from these, moderately diluted, was heated to boiling and precipitated with a $^N/_2$ solution of ammonium oxalate, care being taken to avoid an excess of the reagent. The oxalate was slowly added from a pipette, and with rapid stirring, to prevent as far as possible the occlusion of magnesium with the calcium oxalate. The precipitate was allowed to stand eight to twelve hours before filtering. The well washed precipitate of calcium oxalate, with a small quantity of magnesium oxalate was dissolved in warm, dilute hydrochloric acid and the solution was rendered alkaline with ammonia; this precipitates the calcium oxalate and leaves the magnesium in solution. This amount of magnesium and the main portion from the first calcium-magnesium precipitate were determined separately by precipitating each with disodium phosphate and weighed as magnesium pyrophosphate. The carbon dioxide was determined by the Bunsen method. After the complete analysis was made only the small amount of magnesium, that which precipitates with the calcium, was determined.

I. Determinations by C. C. Carhart.

The specimen was nearly a typical dolomite, containing:

	PER CENT.
$Ca\ CO_3$	53.78
$Mg\ CO_3$	44.96
$Si\ O_2$	0.88
$Fe_2\ O_3$ and $Al_2\ O_3$	0.38
	100.00

The small amount of Mg O—i. e. the quantity precipitated with the calcium was 0.08 per cent.

Eleven other determinations of this amount resulted as follows:

	PER CENT.
1	0.26
2	0.16
3	0.20
4	0.29
5	0.31
6	0.11
7	0.13
8	0.11
9	0.17
10	0.20
11	0.14

This is an average of 0.18 per cent Mg O for the twelve determinations equivalent to 0.378 per cent $Mg\ CO_3$. The amounts obtained are small and indicate that a sufficient quantity of ammonium chloride was added after removing the silica; and also that the ammonium oxalate was slowly added and not in large excess in the precipitation of the calcium. The ammonium chloride forms a double salt with magnesium which renders the latter less likely to precipitate as oxalate.

II. Determinations by F. E. Welstead.

A complete analysis of the specimen gave:

	PER CENT.
$Ca\ CO_3$	50.91
Larger quantity $Mg\ CO_3$	42.01
Smaller quantity $Mg\ O = 0.70\% = Mg\ CO_3$	1.47
$Si\ O_2$	2.08
$Fe_2\ O_3$ and $Al_2\ O_3$	3.51
	99.98

2 Mg O = 0.59% }
3 Mg O = 0.47% } An average of 0.63 per cent.
4 Mg O = 0.75% }

III. Determinations by C. A. Utt.

1. The analysis of the specimen gave:

	PER CENT.
Ca CO_3	52.92
Mg CO_3	37.56
Mg O = 0.47 = Mg CO_3	1.84
Fe_2O_3 and Al_2 O_3	6.26
Si O_2	1.44
	100 02

2 Mg O = 0.96 per cent.
3 Mg O = 0.15 per cent.
4 Mg O = 1.28 per cent.
5 Mg O = 0.47 per cent.
6 Mg O = 0.228 per cent.

In 1, 2 and 4 of this series after dissolving the calcium and magnesium oxalates with hydrochloric acid and precipitating with ammonia the calcium precipitate was at once filtered. It is therefore evident that the calcium was not all precipitated, and afterwards came down and was determined as magnesium. This easily accounts for the large amounts obtained in these determinations.

Next such a mixture of pure Iceland spar and dolomite was taken that the calcium carbonate largely predominated. The analysis of the mixture is given below.

	PER CENT.
CaCO_3	87.035
MgCO_3	10.828
Mg O = 0.47 = MgCO_3	0.990
SiO_2	0.06
Fe_2O_3 and Al_2O_3	1 08
	99.993

2. MgO = 0.15 per cent.

Instead of a gram but 0.2033 gram, not of the mixture but of the original substance was used. The small quantity Mg O was 0.66 per cent. From the foregoing it appears that it makes no difference if the percentage of magnesium is relatively small, or if a small amount of substance is used. About the same quantity of magnesium falls down with the calcium.

IV. Determinations by Miss L. B. Safely.

1. The analysis of the substance showed its composition as follows:

	PER CENT.
$Ca\ CO_3$	41.92
$Mg\ CO_3$	42.10
$Mg\ O = 0.81 = Mg\ CO_3$	1.70
$Fe_2\ O_3$ and $Al_2\ O_3$	13.62
$Si\ O_2$	0.88
	100.22

2 Mg O — 0.81 per cent.
3 Mg O = 0.78 per cent.
4 Mg O = 0.80 per cent.
5 Mg O = 0.72 per cent.
6 Mg O = 1.20 per cent.

In the last case some calcium precipitated with the magnesium because the calcium precipitate was not allowed to stand. Next used a mixture of Iceland spar and dolomite in which the calcium carbonate largely predominated.

1 Mg O = 0.47 per cent.
2 Mg O = 0.47 per cent.
3 Mg O = 0.47 per cent.
4 Mg O = 0.54 per cent.

Instead of a gram, used 0.3518 gram of the original dolomite, Mg O = 0.25 per cent.

Again 0.2133 gram gave 0.03 per cent.

Next a specimen of magnesite was used in which the amount of $Ca\ CO_3$ was only 1.30 per cent. The small amount of Mg O was 0.26 per cent. The conclusion seems to be that the magnesium precipitated with the calcium varies from an almost inappreciable amount to a considerable quantity. It is therefore always better to dissolve the unwashed precipitates of calcium and magnesium in warm hydrochloric acid, then to add ammonia to precipitate the calcium. After standing a sufficient time the calcium may be filtered, and the filtrate can be added to the solution containing the main portion of the magnesium, or the two portions can be separately treated.

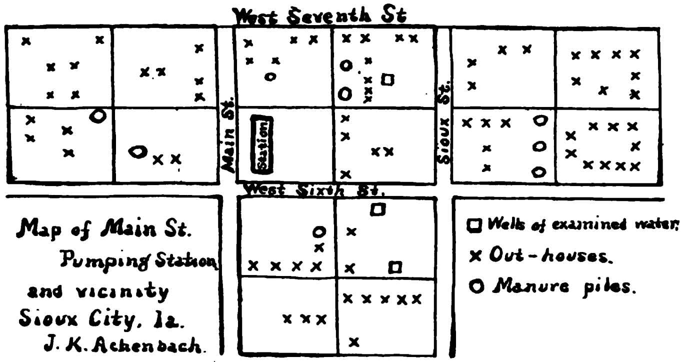
THE SIOUX CITY WATER SUPPLY. III.

BY ALFRED N. COOK.

Examination of various waters in Sioux City has been carried on at intervals during the past year. It will be observed by comparison with analyses of former years that there has been great fluctuation in the detrimental characters of the city water. During the past fall, for several months, the albuminoid ammonia reached and passed the danger limit. This is the first time this has been noted since this series of analyses was begun, although it was pointed out in an article published in the *Sioux City Tribune* over a year ago that this was likely to take place at some time in the future. The analysis made in February shows that the water was in fair condition again. Numbers 1 and 2 are used by permission of the president of the board of waterworks trustees. Numbers 1, 3 and 4 were drawn at Morningside college. Number 2 was furnished by Mr. Healy, president of the above mentioned board.

	No. 1.	No. 2.	No. 3.	No. 4.
	A. N. Cook, analyst, March, 1903.	A. N. Cook, analyst, April 13, 1903.	Herbert Saylor, analyst, Dec., 1903.	John K. Ackenback, analyst, Feb., 1904.
Total solids dried at 110°C	414	427	431	422
Chlorides	9.26	8.36	13.08	10
Nitrogen as nitrates	.75	2	3.09	1.5
Nitrogen as nitrites	None	Trace	None	Trace
Nitrogen as free ammonia	.023	.0138	.048	.0396
Nitrogen as albuminoid ammonia	.000	.0162	.160	.0370
Oxygen consuming power	0.3	.2	.7	.4

The source of the contamination of the water supply is not far to seek. Within two blocks of the main street pumping station in all directions there are several manure piles and over fifty out houses. There are also nine wells within the area which pierce the so-called "impervious stratum of clay," which, by the way, is loess, and below this there is coarse sand and gravel. The city wells are said to be ninety feet deep. The following cut represents the area:



The following analyses of the water of three wells of this region were made by Mr. John K. Ackenback. The results here recorded need no comment except that nearly every item in the analyses condemns the water for drinking purposes, yet the water from these wells and many others is used by a large number of people in the region. It is a peculiar fact that those who live nearest the city water works make the least use of the city water.

	No. 1.	No. 2.	No. 3.
	510 West 6th, Jan. 23, 1904	613 Sioux street, Jan. 23, 1904.	513 Sioux street, Jan. 23, 1904.
Total solids	646.5	612	602
Chlorides	37	23 5	26.3
Nitrogen as nitrates	15	6	6.1
Nitrogen as nitrites	.025	None	Trace.
Nitrogen as free ammonia	.176	.0664	.040
Nitrogen as albuminoid ammonia	.128	.0336	.155
Oxygen consuming power	4.05	2.83	4.3

The analyses recorded below were made by Mr. Saylor. The analysis of the Missouri river water was made from the clear water after the sediment had settled, and the sample was obtained at the combination bridge. It was, therefore, uncontaminated with Sioux City sewage. Both samples of water were obtained in November and December, 1904. The ice was from the crop of 1903.

	Sioux River Ice.	Missouri River.	Sioux River.
Total solids	127	493.5	642
Chlorides	7.14	14.49	7.46
Nitrogen as nitrates	.025	.857	1.57
Nitrogen as nitrites	None.	Trace.	None.
Nitrogen as free ammonia	.2196	051	.293
Nitrogen as albuminoid ammonia	.153	.1407	.056
Oxygen consuming power	2.13	4.225	2.13

Other analyses of Sioux City waters have been made during the year but are not available for publication.

NOTE.—The analysis on page 123, vol. X, which is reported as manufactured ice, is Sioux river ice.

A NEW DEPOSIT OF FULLER'S EARTH.

BY ALFRED N. COOK.

A few months since a prospector brought me a specimen of earth of uncommon appearance from the Black Hills of South Dakota for analysis with the hope that it might be something of value. It proved to be Fuller's earth of exceptional quality and I considered the result of sufficient interest to be published. Below is given the result of the analysis of the specimen dried in the air for two years. Two other analyses from the literature available are given for the sake of comparison. The per

cents of the constituents of a theoretically chemically pure hydrated aluminum silicate with five molecules of water of crystallization are also given.

	South Dakota.	Reygate, England.	Quincy, Florida.	$Al_2[SiO_3]_2$, $(SiO_2)_2$, $(OH)_2$, $5H_2O$.
Silica (SiO_2)	51.28%	52.81%	62.82%	53.33%
Alumina (Al_2O_3)	20.43	6.92	10 35	22.67
Water (H_2O)	20 81	14.27	7.72	24.00
Calcium oxide (CaO)	.87	7 40	2 43	....
Magnesia (MgO)	.40	2.27	3.12	....
Ferric oxide (Fe_2O_3)	2.42	3.78	2.45	....
Potassa (K_2O)	1.89	.74	.74	....
Soda (Na_2O)	.54	....	.20	....
Sodium chloride (NaCl)	.48	....	....	....
Sulphuric oxide (SO_3)	.57	....	....	....
Total	99 64%	....	....	100 00 %

The iron must exist in the state of ferric oxide since it is all dissolved out by hydrochloric acid on digesting on a water bath for a few minutes. The constituents: magnesia, lime, soda and potassa must be in the form of silicate, except that which exists in the form of chloride and sulphate. When the silica combined with the magnesia, lime, etc., is subtracted from the total silica, the amount of alumina, water and the remaining silica is in fair accord with the formula, $Al_2O_3(SiO_2)_4$, $3H_2O$, $2H_2O$. How near this analysis accords with the formula is shown by the following table. The second column of figures gives the amount required by theory, using the amount of silica found as a basis for calculation.

	FOUND.	CALCULATED.
Silica (SiO)	48.45	48.45
Alumina (Al_2O_3)	20.43	20.59
Water (H_2O)	20.81	21.80

Two samples heated in the air both at 100° C. lost in weight corresponding to two molecules of water. It quickly disintegrates in water yielding a whitish emulsion and on

settling is very translucent. It adheres to the tongue and has a slightly styptic taste, probably due to a little dissolved alum as there are some alum springs near by. It has a slightly acid reaction to litmus. It absorbs the coloring matter from ink and removes the grease from cloth. I do not have access to a very large amount of mineralogical literature, but the analyses that have been found compare with it very unfavorably. I believe it must be one of the purest products known. The deposit is believed to be fairly extensive.

THE LICHENS OF "THE LEDGES," BOONE COUNTY, IOWA.

BY KATY A. MILLER.

The study of the flora of "The Ledges" furnishes much opportunity for interesting research. Besides possessing some of the most beautiful scenery of Iowa these ledges, with their moisture and shade, make an inviting habitat for plants of many kinds. Of these plants the lichen flora is perhaps the most interesting, because heretofore little work has been done on the flora of perpendicular sandstone exposures, such as are here presented.

"The Ledges" are of ferrugenous sandstone, rising in some places to a height of seventy-five feet. They present an almost perpendicularly exposed wall for about two miles along the Peese creek, a tributary of the Des Moines river. Disintegration seems to have gone on slowly, for many crustose thalli are well developed. In places where disintegration has gone on to any extent the refuse falls to the water below, so *Cladonias* are found only on the sandstone of the exposed faces and are comparatively rare. Such tree forms as *Parmelias*, *Physias* and *Ramalinas* were found on the sandstone, and such a typical tree form as *Usnea barbata* was collected only from the sandstone. These occurrences are explained by the nearness of trees from which these forms have migrated, and which afford abundant shade and moisture for them.

The study of these lichens has well repaid us, as several species new to Iowa were found, these being *Acarospora (Lecanora) cervina* var. *oligocarpa*, *Verrucaria viridula*, *Bil-*

imbia sp, *Cladonia pyxidata* var. *chlorophœa* and *Cladonia fimbriata* var. *coniocrœa,* which has hitherto been reported in Iowa under *Cladonia fimbriata* var. *tubœformis,* and which likewise included *Cladonia fimbriata apolepta,* also found at "The Ledges." Most of the forms found here have good cellular cortices, and the thalli are larger and better developed than the thalli of the same species which grow in more exposed places.

The following list of lichens is the collection made at "The Ledges" last summer by Miss Charlotte King and Dr. Bruce Fink. In my determinations I am much indebted to Dr. Fink for help in some particularly difficult forms, and also for the use of his lichen herbarium for purposes of comparison and reference.

A set of the lichens herein listed is placed in the herbarium of the Iowa State college at Ames.

Ramalina calicaris (L.) Fr. var. fraxinea (L.) Fr. Lich. Eur. 30. 1831.
On sandstone and trees, rare.

Ramalina calicaris (L.) Fr. var. fastigiata (Pers.) Fr. Lich. Eur. 30. 1831.
On sandstone and trees, common.

Ramalina calicaris (L.) Fr. var. farinacea. (L.) Fr. Lich. Eur. 31. 1831.
On sandstone, rare.

Usnea barbata Fr. Sched. crit. Lich. Suec. 8:34. 1826.
On sandstone, infrequent.

Theloschistes polycarpus (Ehrh.) Tuck. Syn. 1:50. 1882.
On trees, rare.

Theloschistes lychneus (Ach.) Th. Fr. Lich. Scand. 1:146. 1871.
On trees, rare.

Theloschistes concolor (Dicks.) Th. Fr. Scand. 1:147. 1871.
On trees, rare.

Parmelia crinita Ach. Syn. Meth. Lich. 196. 1814.
On sandstone, common.

Parmelia tiliacea (Hoffm.) Ach. Meth. Lich. 215. 1803.
On trees, infrequent.

Parmelia borreri Turn. in Trans. Linn. Soc. 148. 1808.
On trees, frequent. (Young for m.)

Parmelia borreri Turn. var. rudecta (Ach.) Tuck. Syn. Lich. New Eng. 26. 1848.
On sandstone, common.

Parmelia caperata (L.) Ach Meth. Lich. 216. 1803.
On rocks, infrequent.

Physcia hypoleuca (Ach.) Tuck. Syn. Lich. New Eng. 33. 1848.
On trees, frequent.

Physcia speciosa (Wulf.) Nyl. in Act. Soc. Linn. Bord. (Ser. 3) 1:307. 1856.
On rocks, rare. (Cortex of hyphae.)

Physcia pulverulenta (Schreb.) Nyl. Act. Soc. Linn. Bord. (Ser. 3) 1:308. 1856.
On sandstone, frequent.

Physcia stellaris (L.) Tuck. Obs. North Amer. Lich. 395. 1860.
On trees, common.

Physcia asteroidea (Fr.) Nyl. Act. Soc. Linn. Bord. (Ser. 3) 1:308. 1856.
On trees, infrequent.

Physcia caesia (Hoffm.) Nyl. Act. Soc. Linn. Bord. (Ser. 3) 1:308. 1856.
On trees. (Species generally supposed to occur only on rocks. Iowa species have formerly been referred to *Physcia granulifera*, but upper cortex is cellular.)

Physcia obscura (Ehrh.) Nyl. Act. Soc. Linn. Bord. (Ser. 3) 1:309. 1856.
On granite, rare, but common on trees.

Physcia adglutinata (Flk.) Nyl. Syn. Lich. 428. 1860.
On trees, rare.

Peltigera rufescens (Neck.) Hoffm. Deutschl. Fl. 2:107. 1795.
On shaded earth, rare.

Peltigera canina (L.) Hoffm. Deutchl. Fl. 2:106. 1797.
On earth, rare.

Peltigera canina (L.) Hoffm. var. sorediata (Schaer.) Tuck. Syn. North Amer. Lich. 1:109. 1882.
On shaded rock and sandstone, rare.

Peltigera canina (L.) Hoffm. var. spuria (Ach.) Tuck. Syn. North Amer. Lich. 1:109. 1882.
On earth, rare.

Pannaria nigra (Huds.) Nyl. Lich. Scand. 126. 1861.
On sandstone, abundant.

Amphiloma (Pannaria) laguinosa (Ach.) Nyl. Prod. Lich. Gall. et. Alg. 69. 1857.
On sandstone, abundant.

Collema pulposum (Bernh.) Ach. Syn. Lich. 311. 1814.
On sandstone, rare.

Senechoblastus (Collema) nigrescens (Ach.) Stitzenb. Beit. zur Flechtensyst 144. 1862.
On trees and sandstone, rare.

Leptogium lacerum (Sw.) Nyl. Syn. Lich. 1:122. 1858.
On mossy sandstone, rare.

Leptogium pulchellum (Ach.) Nyl. Syn. Lich. 1:123. 1858.
On trees, rare.

Leptogium chloromelum (Sw.) Nyl. Syn. Lich. 1:128. 1858.
On mossy rocks, rare.

Placodium citrinum (Hoffm.) Leight. Lich. Fl. Great Brit. 177. 1871.
On sandstone, rare, (Thallus and fruit larger and darker than usual.)

Placodium aurantiacum (Lightf.) Naeg. and Hepp. Spor. der Flecht. Eur. 1853.
On sandstone, common.

Placodium cerinum (Ehrh.) Naeg. and Hepp. Spor. der Flecht. Eur. 1853.
On trees, common.

Placodium cerinum (Ehrh.) Naeg. and Hepp. var. sideritis Tuck. Syn. North Amer. Lich. 1:175. 1882.
On granite, rare.

Placodium cerinum (Ehrh.) Naeg. and Hepp. var. ulmorum Fink in herb. var. nov.
On elms, rare.
Placodium vitellinum (Ehrh.) Naeg. and Hepp. Spor. der Flecht. Eur. 1853.
On sandstone, common.
Placodium vitellinum (Ehrh.) Naeg. and Hepp. var. aurellum (Hoffm.) Tuck. Syn. North Amer. Lich. 1:180. 1882.
On trees, infreqent.
Lecanora muralis (Schreb.) Schaer. Lich. Helv. Enum. 66. 1822.
On sandstone, rare.
Lecanora subfusca (L.) Ach. Lich. Univ. 393. 1810.
On trees, infrequent.
Lecanora subfusca (L.) Ach. var. argentata Ach. Lich. Univ. 393. 1810.
On trees, common.
Lecanora varia (Ehrh.) Ach. Lich. Univ. 377. 1810,
On cedar, frequent.
Acarospora (Lecanora) cervina (Pres.) Kbr. var. oligocarpa (Nyl.) Fink.
On sandstone, rare. *Lecanora fuscata* (Schrad.) Th. Fr. of the former reports. (Spores 14-16 in ascus. $\frac{11-16}{7-10}$ mic.)
New to Iowa.
Rinodina sophodes (Ach.) Kbr. Syst. Lich. 122. 1855.
On trees, rare.
Rinodina sophodes (Ach.) Kbr. var. exigua (Ach.) Tuck. Syn. North Amer. Lich. 1:208. 1882.
On wood, rare (Hypothecium frequently becoming dark).
Pertusaria velata (Turn.) Nyl. Lich. Scand. 179. 1861.
On trees, rare.
Pertusaria multipuncta (Turn.) Nyl. Lich. Scand. 179. 1861.
On trees, rare.

Urceolaria scruposa, Ach. Meth. Lich. 147. 1803.
On sandstone, frequent.

Cladonia symphycarpa Fr. Lich, Suec. 1826.
On earth, rare. (Not recognized as a distinct species by Wainio, but placed under *Cladonia cariosa*. We can not put our Iowa forms there. Ours are somewhat like *Cladonia turgida*.)

Cladonia mitrula Tuck. in Darl. Fl. Cestr. 444. 1853.
On sandstone, frequent.

Cladonia pyxidata (L.) Hoffm. var. chlorophaea (Spreng.) Flk. Clad. Comm. 70. 1828.
On sandstone and earth, common. New to Iowa.

Cladonia fimbriata (L.) Fr. var. coniocraea (Flk.) Wainio Mon. Clad. Univ. 2.308. 1894.
On old wood, infrequent. (Hitherto reported in Iowa under name of *Cladonia fimbrata* var. *tubaeformis* Fr., which has also included *Cladonia fimbriata* var – *apolepta*.)

Cladonia fimbriata (L.) Fr. var. apolepta (Ach.) Wainio Mon. Clad. Univ. 2:307. 1894.
On earth, rare.

Cladonia delicata (Ehrh.) Flk. Clad. Comm. 7. 1828.
On old logs, rare.

Cladonia cæspiticia (Pers.) Flk. Clad. Comm. 8. 1828.
On sandstone, rare. (Running into *Cladonia mitrula*.)

Cladonia furcata (Huds.) Schrad. Spicil. Fl. Germ. 107. 1794.
On earth, frequent.

Cladonia sylvatica (L.) Hoffm. Deutschl. Fl. 114. 1796.
On earth, rare.

Cladonia cristatella Tuck. Syn. Lich. New Eng. 55. 1848.
On stumps. (Specimen lost.)

Bacidia (Biatora) inundata (Fr.) Kbr. Lich. Fl. Germ. 187. 1855.
On lime rock.

Bilimbia (Biatora) sp. Fink in herb. (Near *Bacidia sphaeroides* and *B. operxanthroides*.)
On wood. New to Iowa.

Buellia spuria (Schaer.) Arn. Flora. 291. 1872.
On rocks. (Tending toward *Buellia lepidastra*, as margins of apothecia are more or less evanescent and thallus is quite as near that of the latter.)

Buellia parasema (Ach) Kbr. Syst. Lich. 228. 1855.
On trees, rare.

Buellia myriocarpa (D. C.) Mudd. Man. Brit. Lich. 250. 1861.
On old wood, frequent.

Opegrapha varia Ach, Lich. Univ. 259. 1810.
On trees, infrequent.

Graphis scripta (L.) Ach. Lich. Univ. 265. 1810.
On trees, common.

Arthonia lecidella Nyl. Enum. Cener. Lich 337. 1858.
On trees and sandstone, frequent.

Arthonia radiata (Pers.) Th. Fr. Lich. Arc. 240. 1860.
On trees, common.

Arthothelium spectabile (Flk.) Stiz. Beitr. Flechtensyst. 152. 1862.
On trees, infrequent.

Calicium quercinum Pers. Tentam. dispos. Fung. suppl. 59. 1797.
On trees, rare.

Calicium quercinum, tending toward var. subcinium. Nyl. Syn. Meth. Lich. 8:156. 1858.
On trees, rare.

Calicium parietum Ach. in Veg. Acad. Handl. 260. 1816.
On red cedar, rare.

Dermatocarpon (Endocarpon) pusillum (Hedw.) Schneider. Text. Licht. 189. 1897.
On sandstone, rare.

Verrucaria nigriscens Pers. in Uls. Ann. de Bot. 14:36. 1795.
On sandstone, frequent.

Verrucaria viridula Ach. Lich. Univ. 675. 1810.
On granite, rare. (Thallus of the characteristic color but too scanty to be certain that it is not V. nigrescens.)
New to Iowa.

Verrucaria fuscella (Turn.) Ach. Lich. Univ. 289. 1810.
On sandstone, rare.

Pyrenula gemmata (Ach.) Naeg. in Hepp. Flecht, Eur. 51. 1867.
On trees, frequent.

Pyrenula nitida (Schrad.) Ach. Mong. in Berl. Magaz. 21. 1812.
On oaks, rare.

Pyrenula quinqueseptata (Nyl.) Tuck. Genera Lich. 173. 1872.
On trees, frequent.

A METHOD FOR THE DETERMINATION OF CHLORIC ACID.

BY W. S. HENDRIXSON.

In the methods for the determination of chloric acid by reduction, metallic zinc in some form and ferrous sulphate have been the reducing agents most used, though sulphur dioxide and formaldehyde have also been employed. The conditions under which the two former reducing agents have been used have been much varied. Thus Thorpe and Eccles * used the zinc-copper couple, and determined with a solution of silver the chloride formed from the chlorate. Bothamley and Thompson † showed that the results by this method were too low unless sulphuric acid was added near the end of the reduction to dissolve any basic salts of zinc. By the same method Becker ‡ found the results too low and preferred to use zinc dust and a little copper sulphate. Fleissner § used zinc dust and boiled the neutral solution one hour, but Becker attained complete reduction only by using a large excess of zinc dust with sufficient sulphuric acid to dissolve it completely without the aid of heat.

Stelling ‖ reduced chlorates by long boiling in an alkaline solution of ferrous sulphate, and determined the resulting chloride. Becker found that the reaction was very slow and incomplete, and recommended a neutral

* Jour. Chem. Soc Lond., 11, 541; 14, 856.
† Jour. Chem. Soc. Lond., 53, 164.
‡ Repert. d. Anal. Chem., 1, 377.
§ Zeit. d. Anal. Chem., 20, 115.
‖ Zeit. d. Anal. Chem., 6, 32.

solution of ferrous sulphate. Carnot* reduced the chlorates in bleaching powder by heating at 100° and in the presence of sulphuric acid with about twenty times the theoretical amount of ferrous ammonium sulphate. The amount of chloric acid was found either by titrating the resulting chloride by Volhard's method or by titrating the excess of ferrous sulphate with potassium permanganate. Rosenbaum† states that chlorine will be lost in this method of reduction if the acid and ferrous sulphate are added to a hot solution of the chlorate.

In the course of my own work on the action of chloric acid on metals, it was observed that metallic iron very readily reduces chloric acid even in very dilute solutions. At ordinary room temperature the solution of the metal is very rapid in moderately concentrated solutions, and in any case the iron goes at once into the ferric condition, as was proved by many tests while solution was going on. No gas is evolved, but the iron simply disappears and there results the yellowish-brown solution of a ferric salt, if the acid is in excess. Whether iron alone reduces chloric acid completely could not be determined owing to the large amount of iron oxide, and possibly insoluble basic salt, which were formed, and which made it impracticable to obtain a solution suitable for titration with silver without the use of a reducing agent and sulphuric acid. An approximation, however, showed that about 95 per cent of the chloric acid was reduced.

These facts suggested that the determination of chloric acid might be brought to a very simple form by using metallic iron as the chief reducing agent in the presence of an excess of sulphuric acid, which would prevent the formation of insoluble compounds, make the method applicable to chlorates by setting free the chloric acid, and form ferrous sulphate which is itself a reducing agent for chlorates, and which would already be present to serve when oxidized as the indicator in the titration of the chloride by the method of Volhard. It is evident, there-

*Compt. Rend., 122, 449 and 452
† Zeit. d. Angew. Chem. 1898, 80.

fore, that such a method would be a combination of the two already mentioned, the reduction of a chlorate by a metal and a more efficient one than zinc, and the reduction by ferrous sulphate.

To carry out the method a weighed amount of pure potassium chlorate or a measured amount of chloric acid was placed in a small flask with about 50 c.c. of pure sulphuric acid having a concentration of about 10 per cent, and an excess of "card teeth", used in most laboratories. In some of the experiments recorded below, the flask was fitted with a delivery tube, dipping into water, the purpose being to prevent the possible loss of hydrochloric acid, but this precaution was found to be wholly unnecessary. At first ferric salt is formed and the liquid becomes yellowish-brown, but the dissolved iron is soon reduced and the solution becomes colorless or slightly green. If all the chlorate is dissolved at the beginning, the disappearance of the yellow color may be taken to mark the end of the reduction, which requires at room temperature about one hour. No doubt the reduction could be hastened by heating, if precautions were taken to prevent the loss of any hydrochloric acid. As might naturally be expected the method serves quite as well for the determination of bromic acid and bromates as for chloric acid and chlorates, and two determinations of bromic acid in potassium bromate are given below.

After the reduction was completed, the solution was made up to a definite volume, and portions of it were titrated with N/20 silver nitrate. Usually, an excess of silver was added before the iron was oxidized to the ferric condition, to serve as the indicator, by the addition of an excess of nitric acid. There seems, however, to be little danger of the loss of chlorine, if the nitric acid is added before the silver.

The following are results obtained by the method described, the amount of silver required in the titrations being calculated to chloric or bromic acid:

1. 5 c.c. of a solution of chloric acid gave 1.0639. $HClO_3$.
2. 5 c.c. of chloric acid gave 1.0619 $HClO_3$.

   The same solution of pure chloric acid titrated with standard barium hydroxide gave in 5 c.c. 1 0665 $HClO_3$.

		CALCULATED
3.	0 4595 grams $KClO_3$ gave 0.3158 $HClO_3$.	.3165
4.	0.6709 grams $KClO_3$ gave 0.4628 $HClO_3$.	.4622
5.	0.8300 grams $KClO_3$ gave 0.5731 $HClO_3$.	.5718
6.	1.2744 grams $KClO_3$ gave 0.8778 $HClO_3$.	.8778
7.	0.3350 grams $KBrO_3$ gave 0.2605 $HBrO_3$.	.2585
8.	1.0983 grams $KBrO_3$ gave 0.8460 $HBrO_3$.	.8478

The method above described seems to have some advantages. It is extremely simple. It can be carried out at room temperature, avoiding the danger of loss of hydrochloric acid by heat. In the reduction and the preparation of the solution for titration are necessary only iron and pure sulphuric acid and nitric acid which are always at hand in every laboratory, and no filtering or other operations likely to occasion loss of chlorine or loss of time are required.

Iowa College, Grinnell, Iowa.
April 11, 1904.

THE ACTION OF CHLORIC ACID ON METALS.

BY W. S. HENDRIXSON.

In the course of my work a year ago on Silver as a Reducing Agent, in which the action of finely divided silver on chloric, iodic and chromic acids was studied quantitatively, there was occasion to study the literature relating to the action of chloric and related acids on other metals. It soon appeared clear that the amount of information to be gained about the action of chloric acid in particular, on the metals was very meager, and it appeared also that there were several errors, whose origin in most cases could not

be traced, that had apparently come down from treatise to treatise to the present time. It seemed, therefore, desirable to attempt to make some contribution to the subject, and if possible to clear up some contradictions and doubtful points, and this seemed the more desirable since chloric acid is one of the few strong oxidizing acids, which can be obtained in the free state easily and in pure condition, and which is fairly stable.

So far as known to me scarcely any attempt has been made to study quantitatively the action of chloric acid on metals. It is a highly dissociated acid and it is also a strong oxidizing agent. As might be expected, its action on metals may take one or both of two courses. It may dissolve some metals with the liberation of hydrogen in about the same way as hydrochloric acid, and with very little oxidizing action; again, it may act purely as an oxidizing agent. The course depends upon the nature of the metal in any case and the concentration of the acid. Contrary to statements that have been made I do not find any metal that dissolves in chloric acid without the reduction of at least a small portion of the acid. On the other hand, there are several metals that simply disappear in the acid and that rapidly and at ordinary temperature, without the evolution of any gas whatever. Among these are cadmium, copper and iron.

Most of the chloric acid in the market is far from pure, and I have been able to obtain only one sample pure enough for use in this work. It was secured from Eimer and Amend, and it contained no sulphuric acid, barium or free chlorine, and only a trace of hydrochloric acid. This supply was some time ago exhausted and the delay in importing an additional supply has occasioned in some measure the incompleteness of this paper. The acid as received showed by titration that it contained 211.7 $HClO_3$ per liter, or almost exactly the amount corresponding to 2.5 normal acid.

It was very desirable in some of these experiments to hasten the action of the acid by heat. Since it is stated in the literature that chloric acid in water solution decom-

poses into chlorine and perchloric acid, water and oxygen, when heated above 40°, it was deemed necessary to test the stability of the 2.5 N. acid at higher temperatures, and this was done in the following way: A volume of 30 c.c. of the acid of 2.5 N. strength was placed in a tube so arranged that pure air from a gas cylinder could be passed through the acid and then by suitable exit tube into a flask containing potassium iodide. The tube was placed in a beaker of water which could be heated. While a slow current of air was passed through the acid the temperature was slowly raised to the boiling point of the water in the beaker, and the boiling was maintained for half an hour. At about 95° the solution of potassium iodide began to show a trace of color, due to separated iodine. At the end of the experiment the free iodine was titrated with N/10 thiosulphate and required 0. 2 c.c., which corresponds to 0. 6 mg. of chlorine. The strength of the acid then remaining in the tube was found to be 2. 65 N. and on testing with silver it gave apparently only the usual slight opalescence. It seems clear, therefore, that one may heat even the strongest, pure chloric acid that is likely to be found in the market to temperatures near the boiling point of water without fear of essential decomposition. It seems probable that the statement that chloric acid decomposes when heated above 40° might be due to the fact that the author used impure acid, containing possibly hydrochloric acid which might decompose the chloric acid, or that the statement refers to an acid of about the maximum concentration.

The methods of experiment were in general very simple. In some cases where no hydrogen was evolved, the flask or tube containing the weighed metal and measured acid was allowed to stand at room temperature. In cases where the solution was slow, the vessel was placed in water which was heated to 40 or 50 degrees. The conditions are mentioned under the metals to which they apply. Save in two or three cases no attempt was made to exclude the air for the two reasons, that at best the acid would contain some air which could not with safety be expelled by heating, and that in two or three cases where

the solution was carried on in an atmosphere of carbon dioxide the results were not noticeably different from those in the experiments carried out with the same metals in the presence of air. From time to time suitable means were applied to determine whether any chlorine was evolved or any hydrochloric acid was being lost. The tests were negative in every case save in one experiment in the solution of iron. By accident the temperature was allowed to reach 80 degrees, and some chlorine was evolved, and was detected by aspirating a current of air through the acid and into a solution of potassium iodide and starch. To determine the amount of reduction in any experiment the solution was made up to a known volume and portions of it were titrated with N/20 silver solution after the method of Volhard, to determine the hydrochloric acid, from which the amount of chloric acid reduced could be calculated.

Action of Chloric Acid on Sodium and Potassium.

No information as to the action of chloric acid on potassium is known to me in the literature. Tommasi* tried the action of sodium amalgam on the acid and stated that the acid is not reduced to the least extent. I have repeated the experiment of Tommasi, using about two per cent sodium amalgam freshly prepared from carefully cleaned sodium and the usual redistilled mercury. The method of experiment in this instance was to add the amalgam slowly, while the solution of acid was kept cool, to a measured volume of chloric acid. When nearly all the acid was neutralized the solution was poured off, and, together with the washings, was acidified with nitric acid and titrated in the usual way. A blank experiment using water was made to test the freedom of the amalgam from traces of chlorine.

1. 25 c.c. 2N $HClO_3$ treated with 10 grams sodium amalgam required 1.4 c c. N/20 silver solution, corresponding to 0.0025 grams HCl.
2. 25 c.c. 2 N $HClO_3$ treated with a large excess of sodium amalgam required 6.85 N/20 silver solution, corresponding to 0.0125 grams HCl.

*Instituto Lombardo, 2 Ser. X, 799.

Similar results were obtained with potassium amalgam, and the reduction was about twice that produced under similar conditions by sodium amalgam.

1. 25 c.c. 2N $HClO_3$ treated with about 10 grams of potassium amalgam required 2.9 c.c. N/20 silver solution, corresponding to 0.0053 HCl.
2. 25 c.c. N $HClO_3$ treated with 10 grams potassium amalgam required 1.5 c.c. N/20 silver solution corresponding to 0.0027 grams HCl.

From the results there seems to be no doubt that both sodium and potassium amalgam are capable of reducing chloric acid, though the amount of the reduction is very small. In using mercury and an alkali metal there is the possibility that the reduction may be caused by the mercury. In the presence of such a strong electro-positive metal as sodium, however, this does not seem probable. Moreover, on attempting to dissolve mercury in chloric acid it was found that after heating at 40 degrees for four hours scarcely any reduction of the acid had taken place and the remaining mercury was collected, dried and weighed and corresponded within four milligrams to the original amount taken. The smallest amount of HCl found above corresponds to about 0.04 gram of mercury.

Action of Chloric Acid on Magnesium.

Magnesium in the form of the ordinary ribbon of commerce was used. It was cleaned with emery paper and dissolved in an excess of normal chloric acid, 50 c.c. of the acid being used in each case. The amount of metal considered, the reduction caused by magnesium is more pronounced than in the cases of the alkali metals.

1. 0 2918 grams of magnesium gave.......0.0065 grams HCl.
2. 0.2170 grams of magnesium gave.......0.0054 grams HCl.

The results show in fact that about one-twentieth of the magnesium was used in reducing the chloric acid. The remainder, of course, dissolved to form the chlorate with the evolution of approximately its equivalent of hydrogen. Since, as is well known, water containing salts in solution acts on magnesium with the evolution of hydrogen, it did not seem worth while to determine the amount of hydrogen produced in the solution of the metal.

Action of Chloric Acid on Zinc.

Concerning the action of chloric acid on zinc there are many statements in the literature and some contradictions. According to GayLussac* and Berzelius the acid dissolves zinc without decomposition and with the evolution of hydrogen; according to Vauquelin, Fordos and Gelis † with the formation of hydrochloric acid, but without the evolution of hydrogen; according to Gmelin * with both the reduction of the acid and the evolution of hydrogen. Tommasi ‡ states that in one experiment zinc reduced 14 per cent of the free acid present in 100 hours, and that the acid was completely reduced by an excess of zinc and sulphuric acid. Zinc and zinc dust have been used as the reducing agents in determining chlorates, but not so far as known to me for the determination of the free acid, nor does there seem to be any record of quantitative study to determine the nature of the reaction of chloric acid and zinc so far as relates to the relative amount of zinc that reduces the acid and that which sets hydrogen free as the concentration of the acid is varied. In the present series experiments were made with an excess of acid and with an excess of zinc, but the series is not yet complete.

In these experiments and also in those with aluminium, there was used as the vessel in which the reaction took place a graduated tube made from a burette. It was fitted with a rubber stopper and a delivery tube of small bore, such as is used for water thermometers. The tube was filled with acid nearly to the stopper when in place and adjusted in a water bath. The weighed zinc was dropped in, the stopper quickly inserted and the hydrogen was collected in a graduated tube over water. Experiments thus far seem to show that the relative amounts of zinc that set free hydrogen and that reduced the acid may vary widely with the concentration of the acid. In the first two experiments weighed amounts of zinc were used and after the action had practically ceased the remaining zinc was weighed. In each case 25 c.c. of normal acid was used. The chloride

*Gmelin's Handbuch, Vol. 1, 370.
† J. Pharm 4, 346.
‡ Instituto Lombardi, 2 Ser. X, 789. Berichte 11, 345.

formed was titrated and the hydrogen was reduced to normal conditions and the amounts of zinc corresponding to each were calculated. The calculation of the reducing zinc was based upon the assumption that one molecule of the acid oxidized three atoms of zinc, or that when the acid is decomposed at all it is completely reduced to hydrochloric acid, and the whole series of experiments support this view. The volumes of hydrogen given below are in all cases reduced to normal conditions.

	ZINC DISSOLVED.	H. COLLECTED.	HCl. FOUND.	Zn. TO H.	Zn. TO HCl
1.........	0.7047	69.93	0.0925	0.2048	0.4979
2.........	.6627	63.11	.0892	.1857	.4803

In the following an excess of 2 N. acid was used and all the zinc weighed was dissolved, and it was of the same sample as used in (1) and (2). As may be observed in (3) and (4) the amounts of hydrogen collected were very small and the oxidizing action of the acid was very much more pronounced. It was observed in both experiments that the evolution of hydrogen seemed to be very much more rapid near the beginning of the experiment. Though there was scarcely a visible residue it seems possible that as the zinc dissolves, impurities collect at the surface and influence the character of the reaction. This influence would have been far less in (1) and (2) where the zinc taken was about three times the amount dissolved. It is the purpose to investigate this reaction farther, using several samples of redistilled zinc.

ZINC DISSOLVED.	H. COLLECTED.	HCl. FOUND.	Zn. TO H.	Zn. TO HCl.
(3) .3484	4.4 c.c.	.0619	.0129	.3332
(4) .4966	5.7 c.c.	.0873	.0168	.4699

Action of Chloric Acid on Aluminium.

Except the statement of Tommasi * that a solution of chloric acid treated with aluminium showed after six hours only a trace of hydrochloric acid, there seems to be nothing in the literature concerning the action of the acid on this metal. Aluminium slowly dissolves in cold dilute

* l. c.

chloric acid, and whatever the concentration hydrogen is given off and the acid is reduced as in the case of the action of the acid on zinc.

For the following experiments the ordinary aluminium wire of commerce was used. An attempt was made to compare, as in the case of zinc, the action of the dilute acid on an excess of the metal with the action of an excess of the strong acid. In the former case, however, the metal dissolved as indicated by the loss of weight was always too small by about 5 per cent to account for the hydrogen set free and the chloric acid reduced. Determinations of the actual amounts of metal in solution and in the residue showed that in very dilute acid the metal becomes coated with a layer of oxide, which accounts for the above mentioned discrepancy. The ratio of the metal which replaced hydrogen to that which reduced the more dilute acid was found to be about 1 to 7, while in the experiments with the 2 N. acid below the ratio was about 1 to 5.

In the following experiments the aluminium was completely dissolved in 2 N. acid, the hydrogen was collected and reduced to normal conditions and the HCl was titrated in the usual way.

	Al: DISSOLVED.	H. COLLECTED.	HCl. FOUND.	Al. TO H.	Al. TO HCl.
(1)	.2435	47.8	.1363	.03876	.2027
(2)	.2637	55.4	.1386	.04487	.2210

In each experiment there was an insoluble residue of 0.7 milligram.

Action of Chloric Acid on Iron.

The treatises of Graham-Otto and Dammer quote apparently from a very old but undesignated work, that zinc and iron dissolve in chloric acid with the evolution of hydrogen. Schiff* in his correspondence states that Pellagri found that iron reduces chlorates, and Tommasi † partially reduced copper chlorate with iron. There seem to be no other references to the action of iron on either free chloric acid or its salts.

Contrary to the statement mentioned iron dissolves readily in dilute or strong chloric acid without the evolution

* Berichte, 8, 1356.
† (l. c.)

of hydrogen or any other gas. In the following the purest, soft iron wire such as used in standardizing permanganate was used. Even with two or three pieces of this large wire the action was so vigorous that a considerable rise in temperature was occasioned, when the 2N. acid was used. The solution took place in glass stoppered bottles standing in cold water. In several instances a brown coating was observed to form which scaled off and was soon dissolved in the excess of acid. The iron goes directly into the ferric condition, and in no instance, even while the solution was going on, could ferrous iron be detected by the usual tests. The solution has the usual brown color characteristic of solutions of ferric salts but remains perfectly clear so long as the acid is in excess. With a large excess of iron, oxides and probably basic salts are precipitated. In one such case the amount of reduction of the chloric acid was found to be approximately 95 per cent. The very ready reduction of the acid by iron suggests to the writer a method for the determination of chloric acid and chlorates by reduction with iron in the presence of sulphuric acid and the titration of the hydrochloric acid formed.

In the solution of iron, if anywhere, one might expect the oxygen of the air to exert an influence upon the relation of the metal dissolved to the amount of acid reduced. In experiment (4) the solution was carried out in an atmosphere of carbon dioxide. A distilling flask containing the acid was supported so that the neck in which the weighed iron was placed, was in a nearly horizontal position. When the air had been completely expelled by carbon dioxide the neck was raised so that the iron fell into the acid. The results of this experiment do not indicate that the air has any appreciable influence. In the following experiments the iron in column (3) is of course calculated on the basis that it was all oxidized to the ferric condition. In all cases the amounts of iron thus calculated and added to the residues of carbon and silica found in the respective experiments are somewhat smaller than the corresponding amounts of iron weighed. I am not at present able to account for this small difference, and the subject

will receive further attention. In (1) of the following experiments 35 c.c. of normal acid were used at 40 degrees, and in the others 20 c.c. of 2N were used in each case, and the acid was kept at about room temperature.

	IRON WEIGHED.	HCl. FOUND.	IRON CALCULATED.	RESIDUE.
1.	.1609	.0518	.1592	.0011
2.	.2262	.0699	.2148	.0046
3.	.3010	.0949	.2916	.0006
4.	.3220	.1023	.3143	.0014

Action of Chloric Acid on Tin.

The tin used was so-called pure tin obtained from Schuchardt, and the solution took place in glass stoppered bottles at room temperature. In the first experiment 25 c.c. of the 2N. acid were used and the solution occupied about thirty minutes. In the second case 50 c.c. of N. acid were used and the action occupied several hours. Contrary to what might be expected very little tin oxide or stannic acid remained. In each case the residue, which did not increase on long standing, weighed .0022 gram. The solution remained clear for a long time even after it had been diluted preparatory to titration. As in the case of iron, no hydrogen was set free and the tin went at once into the stannic condition, as shown by appropriate tests.

1. .3084 grams of tin gave .0618 HCl, corresponding to .3027 grams tin.
2. .3572 grams of tin gave .0721 HCl, corresponding to .3531 grams tin.

Action of Chloric Acid on Copper.

After the work on copper had been done there came to my notice the communication of Brochet on the solvent action of chloric acid on copper which appeared in Comptes Rendus January 25th of this year. His paper came into my hands after the next paragraph had been written. While granting to Brochet the priority in several particulars, since he gave no analytical data, I deem it best to submit for record the paragraph as originally written.

The action of chloric acid on copper offers no peculiarities. It is just what one in view of the foregoing would expect. The copper simply disappears, and this gives rise

to a clear blue solution due to salts of copper. The copper used was in the form of bright wire gauze, such as is commonly used in combustion in organic analysis. The metal dissolves rapidly in 2N. acid at 50 degrees.

1. .2778 grams copper gave .0528 HCl, corresponding to .2766 grams Cu.
2. .5288 grams copper gave .1000 HCl, corresponding to 5236 grams Cu.

Action of Chloric Acid on Cadmium.

The action of chloric acid on cadmium is in every way similar to its action on copper, it being one of simple oxidation and the solution of the oxide in the excess of acid, no gas being given off. Ordinary commercial cadmium was used. The acid was 2 normal. In the first case the reaction went on at room temperature and in the second at 50°.

1. .4732 grams cadmium gave .0520 grams HCl, corresponding to .4810 Cd.
2. .4091 grams cadmium gave 0438 grams HCl, corresponding to .4052 Cd.

The action of chloric acid on certain other metals has been studied to some extent. It acts with exceeding slowness on mercury and antimony even when at full strength and at 70°, and no attempt was made to determine the quantitative relationship. Nickel dissolves readily and apparently in quite the same way as copper and cadmium. Bismuth is rather slowly oxidized and only a small portion of the product goes into solution. In one experiment .3693 grams of bismuth gave .0282 HCl, corresponding to .3624 Bi.

In a recent communication on silver as a reducing agent* it was shown that silver reduces chloric and iodic acid directly to hydrochloric and hydriodic acids, and according to the equation as there given for chloric acid.

$$6Ag+6HClO_3=5AgClO_3+AgCl+3H_2O.$$

The same general reaction has since been found to hold true in the case of bromic acid and silver. There was no evidence in any case of the formation of any intermediate product, in the reduction of the acid, but in each case the reaction ran smoothly as above represented. Omitting the

* HENDRIXSON, Jour. Amer. Chem. Soc. 25.

matter of the evolution of hydrogen the same reaction holds true in general of the action of chloric acid on other metals. In no case when the temperature has been kept moderately low has there been evidence of the formation of a lower acid, an oxide of chlorine or free chlorine. Save in the case of iron, where the question of impurity is uncertain, the amount of metal dissolved has been accounted for by the amount of reduction of the acid, or the reduction and the hydrogen set free. It is possible that some irregularity in the reaction took place in the case of iron and in other instances, even though it was not detected. Since chloric acid is almost as highly dissociated as hydrochloric acid it must be that a large portion of the HCl formed by the reduction exists in the solution in the free condition, and it might be expected that the two acids would act upon each other according to some one of their known reactions. If such action occurs its extent must evidently be quite small.

There is yet a persistent tendency as shown in chemical literature to regard the reduction of an acid in its action on a metal, as in the case of the action of hot sülphuric acid on copper, as due to the "nascent" hydrogen first set free. Thus,

$$Cu+H_2SO_4=H_2+CuSO_4$$
$$H_2+H_2SO_4=2H_2O+SO_2.$$

In the case of chloric acid, however, we have all varieties of reaction, from that of the action of the acid on sodium and potassium, where nearly the full equivalent of the hydrogen is set free and the reduction of the acid is extremely small, to that of the action of the same acid on iron, tin and copper, in which no hydrogen is set free and nearly or quite the full equivalent of the metal appears in the amount of reduced acid. It would seem, therefore, that since the temperature is practically the same in all cases, as well as the concentration of the acid, that the reduction can not be accounted for on the basis of nascent hydrogen. In each case it seems to be rather a mere question of the tendency of the metal, under the conditions, to oxidize at the expense of the oxygen of the acid, or, to go

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into solution at the expense of the hydrogen which is set free. In the cases of iron, tin and bismuth it seems evident to the eye that oxides are first formed, and in all cases where reduction occurs the view is simplest and most nearly in accord with the facts, that the metal is oxidized and that the oxide dissolves in the excess of the acids, or remains insoluble as in the case of bismuth.

Iowa College, Grinnell, Iowa.
April 11, 1904.

PERIODICAL LITERATURE IN IOWA ON THE SUBJECT OF CHEMISTRY.

BY W. S. HENDRIXSON.

The following is a list of the chemical periodicals in the State of Iowa, with the extent of the files and the names of the libraries in which they may be found. The list is prepared and published for the information of chemists who may have occasion to refer to such periodicals in their work. So far as known the books of any file may be used for reference purposes in the libraries which contain them and under certain restrictions, in some cases, they may be taken out for purposes of reference. In some cases the books are in the private libraries of chemists connected with the institutions mentioned, but this does not preclude their use by outside parties.

In this list are not included fragments of sets consisting of only a few volumes, unless the periodicals are now being received. The extent of the files is indicated by years. The libraries in which the periodicals are to be found are designated as follows: State University of Iowa, S. U. I.; State Library, S. L.; Iowa State College, I. S. C.; Iowa College, I. C.; Morningside College, M. C.; Drake University, D. U.; Cornell College, C. C.; Coe College, Coe; Simpson College, S. C.; State Normal, S. N.; Sioux City Library, S. C. L.

Annalen der Chemie, Liebig's.
S. L., 1832-1895; S. U. I., 1887—; M. C., 1900—.
American Chemical Journal.
S. U. I., complete; I. C., complete; I. S. C., complete; S. N., 1894—; C. C., 1900—; S. C.; 1902—; S. C. L., 1892.
American Journal of Science.
S. L., complete; S. U. I., complete; I. S. C., complete; I. C., 1852—1891; M. C., 1892—.
Bulletin de la Societe Chimique. de Paris.
S. U. I., complete; D. U., 1895—; M. C., 1900; I. C., 1904.
Bulletin de l'Association Belge Chimistes.
S. U. I., complete.
Berichte der Deutschen Chemischen Gesellschaft.
M. C., complete; I. C., complete; S. U. I., 1872—; D. U., 1895—; C. C., 1898—.
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REGENERATION IN THE CRAYFISH.*

BY JOHN J. LAMBERT.

In working over a series of crayfishes for class purposes, certain quite suggestive facts came to light concerning the regeneration of the appendages under the conditions of normal environment. The specimens examined were mature males and females taken directly from their natural surroundings. While not imputing lack of value to experimental work in the field of regeneration, it certainly is true that nature and the laboratory are two very different things. It is therefore felt that the following notes, while preliminary in character, are of sufficient value for publication.

One hundred and forty individuals were examined, fifty-five of which were females, eighty-five males. Of this number twenty females and twenty-eight males, forty-eight in all, had one or more appendages wanting.

The following chart was prepared to set forth these facts in a concise and systematic way. While it may not give as much as would be desirable, still the main suggestive points are indicated.

* From the Laboratory of Animal Morphology, State University of Iowa, Gilbert L. Houser, Director.

Individuals		Appendages.														Remarks.
		Antennæ.				Chelipeds.		Walking-Legs.								State or Progress of Regeneration.
		I.		II.				1st.		2nd.		3rd.		4th.		
Male.	Female.	Right.	Left.	Right.	Left.	Right.	Left.	Right.	Left.	Right.	Left.	Right.	Left.	Right.	Left.	
1				x												1st joint only, left; ½ regenerated.
2					x		.5									Antenna 1st joint, left; chela regenerated.
3					x											¾ of 4th pleopod wanting also; no regeneration.
4				.5			.5									Chela ½ regenerated.
5							.5									Chela ⅓ regenerated.
6						x	x									Right chela ⅔ regenerated; left begun.
7				x	x	x										No regeneration.
8		x	x													½ of both wanting.
9		.5	.5	.5						Mer.						No regeneration.
10						x										No regeneration.
11					.5											No regeneration.
12						x										⅔ of dactylopodite missing.
13				x		x										No regeneration of antenna; chela ⅜ regenerated.
14						x										Chela ½ regenerated.
15						x										Chela ⅔ regenerated.
16		x	x	x						x						No regeneration.
17				x		x	x	x		x						Antenna ½ regenerated.
18				.5	.5	x	x									Left antenna ½ regenerated.
19						x	x									Chelæ ½ regenerated.
20				x	x	x										Antenna ½ wanting; chela ⅜ regenerated.
21						x		Bas.								No regeneration.
22						x										Chela ⅓ regenerated.
23						x										Chela ⅔ regenerated.
24						x	x									Chela ½ regenerated.
25							x					Bas.			Bas.	Chela regenerating.
26							x									No regeneration.
27							x									No regeneration.
28						x										Chela ½ regenerated.
Totals...		3	3	9	6	16	11	2	0	3	0	1	0	0	1	Total number of injuries, 56, with pleopod,

	1							Isch.		Isch.						No regeneration.
	2					x	x									No regeneration.
	3											x				No regeneration.
	4					x										Chela ¾ regenerated.
	5			.5	.5											Both ½ wanting.
	6			.3	x	x	x						x			No regeneration.
	7			.5		x	x									No regeneration.
	8			x	x	x										Left antenna ½ regenerated; chela ½ regenerated.
	9				.5		x									Chela ½ regenerated.
	10											Isch.				No regeneration.
	11					x	x									Chelæ ¾ regenerated.
	12			.5	.5	x										No regeneration.
	13										Cox.	x				Regeneration.
	14						x									No regeneration.
	15					x	x									Regenerating at the stumps.
	16						x									Chela ⅗ regenerated.
	17					x										No regeneration.
	18					x										No regeneration.
	19						x								Bas.	No regeneration.
	20						x									No regeneration.
Totals ...		0	0	5	5	10	10	1	0	1	1	3	1	0	1	Total number of injuries, 38.
Gr. totals		3	3	14	11	26	21	3	0	4	1	4	1	0	2	Grand total injuries, 94.

Summary of Results.—An examination of the chart reveals the following facts:

1. There was an equal number of injuries to the right and left antennæ of the first order in the males, while in the females none were injured.
2. The injuries to the right antennæ of the second order in the males were 50 per cent greater than those of the left, there being an equal number of injuries in the females.
3. The injuries to the right chelipeds were 50 per cent greater than those of the left in the males, while in the females there were the same number of injuries in the right and the left.
4. The proportion of the injuries to the right and left walking legs in the males was as 6 to 1, in the females as 5 to 3.
5. With the single exception of a male charted as number 3, none of the pleopods were wanting in any of the specimens.
6. Making the total number of individuals the basis of computation, we find that the injuries are distributed as follows:
   (a) The antennæ of the first order show the same number of injuries.
   (b) The antennæ of the second order show the right and left to have injuries in the proportion of 14 to 11.
   (c) There were 25 per cent more injuries to the right chelipeds than to the left.
   (d) The walking legs of the right side had 26.7 per cent more injuries than the left.
7. Only antennæ of the second order and the chelipeds showed regeneration. Forty per cent of the antennæ of the males as compared with 10 per cent of the females, showed regeneration, or 28 per cent for both; while 48 per cent of the chelipeds of the males and 20 per cent of the females or 40 per cent of both revealed a similar condition.

Conclusions.—The results as summarized above seem to indicate that the right appendages are more susceptible to

injury than are the left. While it can not be stated definitely that this is so, it may be that there is a tendency for crayfishes to be "right-handed"—to use their right appendages, especially the chelipeds, more than the left; these are used either offensively, defensively, or in procuring food, and are thus much exposed to the attacks of enemies or accidental injuries.

The antennæ and chelipeds, in most cases, were broken or missing from the "breaking-joint". This was not true with regard to the walking legs as no such joint is distinguished in them; they were missing at various points as indicated by the abbreviations given on the chart.

The almost entire lack of injury to any of the abdominal appendages seems to be due to their small size, their function, and the protection afforded them by that portion of the body as contrasted to the more exposed, larger and more functional thoracic appendages.

At first sight there seems to be a definite relation between the liability of the appendages of the crayfish to injury and their power of regeneration. The appendages more exposed to injury, accidental or otherwise, are the ones in which regeneration is best shown, while those rarely or never injured show apparently but little power of regeneration. But, if we study the process of regeneration more closely, we find this relation to be apparent only, as regeneration takes place in the walking legs of all crustaceans, while the chelipeds alone possess a "breaking-joint". If the walking legs are injured regeneration takes place at any point and there is no definite relation between the liability of a part to injury and its power of regeneration.

The above notes are merely preliminary in character and will be followed later by further results bearing upon other phases of regeneration. A large number of individuals both male and female collected at various seasons will undoubtedly throw much added light upon the subject of regeneration under conditions of normal environment.

A CHEMICAL STUDY OF RHUS GLABRA.

BY A. W. MARTIN.

The Anacardiaceæ, or Sumach family, numbers about four hundred species.

Most of these, however, are tropical; only a few grow in the northern states. Rhus glabra, the one under investigation, is abundant and is one of the hardy species. It grows from two to twenty feet high. The flowers are small and of a greenish-red color. They grow in clusters from three to eight inches long. The fruit consists of red berries subglobular in shape and about 3 m.m. in diameter. They consist of the seed proper within a coating of felt-like husk which contains all of the coloring matter and nearly all of the acid present in the seed.

A water extract of the seed and of the leaves is used for dyeing. The leaves and bark have been used for tanning purposes on account of the large amount of tannic acid present. In a few cases, decoction of the seed has been used medicinally although its real value is questionable.

The seed used in the following experiments was gathered the latter part of September after the full growth had been reached and the seed partly matured. The first work done was on a mixture of two different species, Rhus glabra and Rhus hirta. An examination showed the two species were different and hence the work proper was done on the Rhus glabra.

In beginning the general analysis, the whole seed was used while later it was found advisable to separate the seed from the husk before making the examination.

MOISTURE IN THE WHOLE SEED.

100 grams of the powdered seed, dried at 102 degrees to 110 degrees lost 6.862 grams, 6.8 per cent. The above represents the loss when dried to constant weight at 110° C.

ASH IN THE SEED.

Ten grams of the powdered seed gave 0.2655 gram of ash, or 2.65 per cent of ash.

DETERMINATION OF FREE ACID IN THE SEED.

An examination of the acid properties of the seed showed the free acid to be wholly tannic or gallo-tannic acid. An examination was made by means of a standard solution of sodium hydroxide in which 1 c.c. was equivalent to .01 per cent acid. Five grams of the seed required 52 c.c. of the standard solution, or 10.5 per cent of acid. The above determination was made by simply extracting the seed for some time without grinding it. A second determination was made by first grinding the seed and then extracting as before. In this case 5 grams of the powder required 59 c.c. of standard solution or 12.03 per cent of acid. These determinations with others prove that nearly all of the acid exists in the husk and not in the seed proper.

EXAMINATION OF THE HUSKED SEED.

Some difficulty was experienced in removing the husk from the seed. By adjusting a mill very loosely, it was found that the husk could be removed easily without injuring the seed. Several determinations gave an average of 60 per cent seed, 40 per cent husk.

A determination of the moisture and ash in the hulled seed gave 4.93 per cent of moisture; 2.08 per cent of ash.

DETERMINATION OF OIL IN THE SEED.

The whole seed of the Rhus glabra contains two distinct oils, one in the husk and the other in the seed

proper. The oil in the seed was more carefully studied. Five determinations gave the following:

1. 100 grams of seed gave 9.8 grams of oil.
2. 100 grams of seed gave 8.5 grams of oil.
3. 100 grams of seed gave 9.0 grams of oil.
4. 100 grams of seed gave 9.1 grams of oil.
5. 100 grams of seed gave 9.1 grams of oil.

The average of these determinations is 9.1 per cent of oil.

PROPERTIES OF THE OIL.

The oil is a light colored liquid at the ordinary temperature. At 18 degrees below zero, it changes to a semi-solid.

Its specific gravity at 8° C is 0.931
Its specific gravity at 15° C is 0.9532
Its specific gravity at 18° C is 0.9227
Its specific gravity at 20° C is 0.92

It is readily soluble in ether, chloroform, benzole, carbon-disulphide, and readily so in acetone. It is not a drying oil, as is shown by the following comparison with wheat and linseed oils:

Increase in weight, parts per hundred after—

	5 days	10	15	20	25	30
Linseed Oil................	.037	.130	.28	1.74	4.82	7 55
Wheat Oil.................	.037	.077	.15	.24	.30	.37
Rhus Oil..................	.005	.027	.054	.071	.104	.QRW

The index of refraction was taken with a Pulfrich refractometer at different temperatures with the following readings:

Index of refraction at 0° C......................	1.48821
Index of refraction at 15° C......................	1.48228
Index of refraction at 27° C......................	1 47779

The absorption spectrum of the oil was peculiar. With a film of oil 4 m.m. thick, the whole violet end of the spectrum was cut off and a sharp black band appeared directly over the lithium band. With thicker films, the light was completely cut off.

SAPONIFICATION VALUE.

The saponification value was made by the well known Kottstorfer method. Three determinations gave the following results:

(I) 2.0005 grams of oil required..... 0.3908 grams of KOH.
(II) 1.8923 grams of oil required..... 0.3681 grams of KOH.
(III) 1.9096 grams of oil required......0.3707 grams of KOH.

Calculated milligrams of KOH per gram of oil:

(I)	(II)	(III)	Average.
195.3	194 9	194.13	194.7

IODINE VALUE.

In making the iodine value determination, Hubl's method was followed, results of which were as follows:

1. 0.1611 gram of oil required......0.014155 gram iodine.
2. 0.1668 gram of oil required......0.014339 gram iodine.
3. 0.1737 gram of oil required......0.014848 gram iodine.

Per cent of iodine found:

(1)	(2)	(3)	Average.
87.86	85.96	86.48	86.4

ACID VALUE.

The acid value was determined by the regular method of titrating with standard potassium hydroxide solution. Two determinations gave the following results:

1. 8.5585 grams of oil required......0.02285 gram of KOH.
2. 7.6232 grams of oil required......0.02146 gram of KOH.

Calculated acid value:

(1)	(2)
2.67	2.81

GLYCEROLE DETERMINATION.

Glycerole was determined by the Benedict Zsigmondy method, that is the oxidation of glycerole to oxalic acid by means of potassium permanganate. Two determinations gave an average of 8.81 per cent of glycerole.

UNSAPONIFIABLE MATTER.

In determining the unsaponifiable matter, the method used for the determination of cholesterol was used with the hope of finding one of the known forms of that substance.

The method was slightly modified, using a methyl alcoholic solution of potassium hydroxide instead of the common alcoholic solution. The ether extract of the soap thus formed gave about one per cent of a white crystalline substance which had a melting point of 59° to 60° C. The substance has been preserved for future study. It's melting point and general properties exclude it from the list of known cholesterols.

AN EXAMINATION OF THE HUSK.

One of the characteristic properties of the husk of the sumach seed, is its strong acid property. An examination showed the presence of both tannic and malic acids. An examination of the two acids was made as follows:

100 grams of the dried husk were extracted with hot water and clarified as far as possible by filtration. The filtrate then concentrated by evaporation, a little lime water added and allowed to stand for some time. A reddish granular deposit was formed which on examination, was found to be the calcium salt of malic acid. By filtering and again evaporating, all of the malic acid was separated from the tannic acid. The two lots of the malate were purified and weighed. The tannic acid was determined in the filtrate with the following results:

100 grams of the husk gave 7.32 grams of tannic acid or 7.32 per cent.
100 grams of the husk gave 1.35 grams of the malate or 1.35 per cent.

THE OIL IN THE HUSK.

By extracting the husk with ether, an oil was obtained with different properties from the oil in the seed proper. It appeared almost black when first extracted, had an entirely different odor and solidified at 0° C. At 35° C, it

became a thin liquid and had a specific gravity of .933. It resembles the Rhus oil in some of its properties. It is essentially a non-drying oil.

An average of three determinations of the iodine value gave the following:

1. .1815 gram of the oil gave or required 0.01584 gram of iodine.
2. .1560 gram of the oil gave or required 0.01364 gram of iodine.
3. .1638 gram of the oil gave or required 0.01422 gram of iodine.

Per cent of iodine:

(1)	(2)	(3)	Average.
87.1	87.4	86.74	87.2

The saponification and acid values were, allowing for the difference in the amount of tannic and malic acids, the same as in the Rhus oil proper.

THE UNSAPONIFIABLE SUBSTANCE IN BETA OIL.

By the ordinary method, a large amount of unsaponifiable matter was determined. Several analyses were made, an average of which was 2.26 per cent of the oil. Upon examining the oil, it was found to be of complex nature. The body of the oil seemed to have the same composition as the alpha oil but the substances appearing as impurities were different. The chief substance, however, was the compound which belongs to the so-called unsaponifiable substance group.

During the past few years, several of these compounds have been isolated and some of them analyzed. This work has led us to believe that these substances which are now labelled "Unsaponifiable matter" will be found to be a distinct class of organic substances.

SEPARATION OF THE ALCOHOL FROM THE OIL.

It was found in studying the oil that acetone dissolved about 80 per cent of the oil, leaving behind the remainder as a black, tar-looking oil which contained nearly all of the alchohol. Upon standing, the alcohol precipitated out almost quantitatively. The substance thus obtained, was saponified with alcoholic potassium hydrate and extracted with ether. On evaporating the ether the substance was

obtained as a semi-crystalline mass. The substance is insoluble in water, acids and alkalies. Insoluble in cold alcohol but quite soluble in hot. It is insoluble in acetone but soluble in benzole and ether. Melting point of the pure substance is 63.5 to 65° C.

Analyses of the substance gave the following results:

I. .1006 gram of the substance gave .306 gram CO_2 and .127 gram H_2O
II. .1003 gram of the substance gave .304 gram CO_2 and .1237 gram H_2O
III. .1522 gram of the substance gave .4621 gram CO_2 and .1845 gram H_2O

FOUND.			
(I)	(II)	(III)	
83.	82.75	82.78	C = 82.94
14.104	13.74	13.47	H = 13.34

Calculated for the formula $C_{30}H_{57}OH$.

At this point the material which had been prepared was nearly exhausted and the work still to be completed. An attempt was made, however, to form esters with both acetyl chloride and benzoyl chloride. These would be expected to form readily in the case of a monatomic alcohol. No compound was obtained. The substance, after several hours treatment with either of these chlorides, now melted sharply at 61 degrees C, seemingly due to the removal of slight impurities by this treatment which had still persisted despite repeated purifications by other methods.

It is not possible with the work so far done to conclude that this is or is not an alcohol, especially as it has been found difficult to form esters with the plytesterol of wheat oil by these methods. If the substance should ultimately prove to be only a paraffin, it would be interesting to have found that present in so large an amount in the vegetable kingdom.

PLATE XIV.

Four rock fragments showing specimens of *Nileus vigilans* in the position in which they were found in the undisturbed stratum.

NOTES ON THE POSITION OF THE INDIVIDUALS IN A GROUP OF *NILEUS VIGILANS* FOUND AT ELGIN, IOWA.

BY G. E. FINCH.

David Dale Owen made note more than fifty years ago of the multitudes of fragmentary specimens of *Asaphus iowensis* in an exposure at the junction of Otter creek with the Turkey river at Elgin, Iowa. From then on, that locality has been classic trilobite territory. The most abundant species to be found entire there now, if good trilobites can be said to be abundant anywhere, is *Nileus vigilans*, which occurs both enrolled and more or less straightened in form. Everyone who has collected this species knows it to be gregarious. The collector may look for hours without finding a single specimen, then pick up two or three nice ones in as many minutes. In the summer of 1903 it was my fortune to find in *situ* on a small rock two or three feet in length by one foot in width, some fifteen entire specimens. The place is a rocky run, a mile below Elgin, on the north side of Turkey river; and the horizon is in the Maquoketa shales about forty feet above the base. The stratum in which they were imbedded is of limestone, about two or three inches in thickness and without apparent lamination. Overlying it is a thin, argillaceous, laminated layer separating it from another limestone layer above.

The trilobites found there were all entire ones and belonged to the same species, *Nileus vigilans*, the *Asaphus vigilans* of Meek and Worthen* Some were nearly rolled

*Minn. Geol. Surv. Vol. III, pt. II, page 712, and Geol. Surv. Ills., Vol. II, page 497, and pl. 28, fig. 6.

up, but the majority were about straight. Their prevailing position is: cephalic portion extending horizontally near the surface of the stratum and just appearing at its surface, thorax and pygidium extending downward through the stratum. Different sized individuals maintain the same upper level at the upper surface of the stratum, the larger ones extending farther downward. Their heads sometimes appear flattened as if from vertical pressure, while the thoracic portions are doubled, bent and distorted in several specimens as if from the same cause.

As to why every one of these animals, at the place mentioned, should be found cephalon up we must seek the explanation in their habits. But this quest involves us at once in difficulties because the entire sub-class of which they were members became extinct long ago. We have the authority of Zittel * that little is known of trilobites' habits. It is known from the fossil remains of brachiopods, crinoids, etc., found in their company, that they were salt water animals. Some species preferred deep water, others shallower, and one genus, Trinucleus, lived partly buried in the mud.

The uniformity of position of such a number of fossil remains would defeat the supposition that they were mere empty carapaces shed by moulting individuals. In that case we should have found some remains horizontally placed, or axis downward, or pygidium upward instead of all in the same position. Their pygidia would not have been of sufficient density to sink, and at the same time their cephala buoyant enough to float. If carapaces, some should certainly have had facial sutures open or free cheeks missing.

If, then, as seems evident, they took the position in which they were fossilized, voluntarily as living creatures, can we not from that fact find some light on their condition at that time? It does not seem possible that they hid themselves in burrows, because of their being marine rather than land animals. Their bent and distorted condition also would hardly be the position of such an animal

* Zittel, Text-Book on Paleontology, Eastman's trans. 1, 617.

in a burrow. In addition, cross-setting and polishing or etching the cut surface fails to bring out any circular boundary lines of burrows, such as we should expect the limestone to preserve.

Still the animal could hardly be expected to erect itself on its pygidium, and at first blush it seems ridiculous to suppose that it had the power to press itself backward into the soft mud. But that seems the only tenable theory. It is supported by the character of the pygidium of *Nileus vigilans*, broadly wedged-shaped, stout, and entire of margin. It is likewise supported by the fact that some modern crustaceans have a similar habit.

The facts observed would indicate that this group of trilobites were voluntarily buried posteriorly, and that anteriorly they kept their eyes above the surface of the sediment until, as it rapidly accumulated, they met their death, and were buried by the next layer of rock-forming material.

THE ACTION OF SODIUM THIOSULPHATE SOLUTIONS ON CERTAIN SILVER SALTS.

BY W. M. BARR.

The following work was undertaken at the suggestion of Dr. W. S. Hendrixson, to whom I am indebted for advice and assistance in the work.

The solvent action of the thiosulphates on the halides of silver has long been known, and the fact is almost daily turned to account in the laboratory, and though the reaction has been quantitatively studied to some extent, an examination of the literature shows that no very satisfactory theory of the nature of the reaction and the complexes formed in solution has been established. Rosenheim and Steinhäuser * isolated definite compounds by evaporating saturated solutions of thiosulphates containing all the silver chloride or silver bromide they would dissolve (a compound of definite compositions was not obtained with Ag I), but this does not prove that similar salts are formed in more dilute thiosulphate solutions. Barth † has proposed for the reaction which takes place in such dilute solutions $3\ Na_2\ S_2\ O_3 + 2\ Ag\ (Cl.\ Br.\ I) = (Ag\ Na\ S_2\ O_3)_2\ Na_2\ S_2\ O_3 + 2\ Na\ (Cl.\ Br.\ I)$.

By the solubility determinations of Valenta ‡ it is apparent that the results, even in the case of the chloride, do not accord with the above equation, the amount of chloride being too small to satisfy the equation, the same

* Zeit. Anorg. Chem. 25: 72 and 103.
† Zeit. Phys. Chem. 9: 176.
‡ Berichte der Weiner Acad. 108; Abt. 11 b.

being true in a more pronounced degree in the case of the bromide and the iodide. The iodide in some cases is but one-twentieth the amount called for.

Cohen * has called in question Valenta's results in two particulars. In the case of the chloride he claims that if the thiosulphate solution is agitated with a large excess of AgCl, a slightly soluble salt $(Ag\,S_2\,O_3\,Na)_2$ is formed which separates out. He submits experimental results of his own, supporting his theory and implies that the same is true for the iodide and bromide. He questions whether Valenta obtained saturation in the case of the last two salts. It seemed desirable, therefore, to study the solubility of the iodide, at least, and the effect of temperature upon the solubility of the bromide as well as the iodide. It seemed probable that some light upon the complexes formed might be gained by using some insoluble salt of silver whose acid radical was very different from the closely similar chlorine bromine and iodine, and for this salt silver iodate was chosen, which so far as known to me has not been studied with reference to its action on thiosulphates.

Richards and Faber† made determinations of the solubility of silver Bromide in sodium thiosulphate solutions of varying concentration, also making a few determinations with silver chloride, in all cases working at a temperature of 35°. Valenta's experiments were made apparently at room temperature.

For the determinations of the iodide, pure silver iodide was prepared by precipitating a solution of pure silver nitrate with an excess of pure potassium iodide solution. The precipitate was thoroughly washed and dried at 150°, Solutions of known strength of sodium thiosulphate were made by dissolving weighed amounts of the pure recrystallized salt in recently boiled water, a fresh solution being used in each experiment. An excess of the AgI was placed in the thiosulphate solution in a tightly closed tube and agitated for several hours, the temperature at first being kept several degrees above that at which solubility was to

* Zeit. Phys. Chem. 18: 61.
† Am. Chem. Jo. 21: 167.

be determined, then dropping to the final temperature and running for at least one hour. This was done to insure saturation. Five hours agitation was found to be sufficient time. At the end of this period the precipitates were allowed to settle, a portion of the clear liquid pipetted off and weighed, the Ag precipitated by ammonium sulphide, filtered off, washed, dissolved in hot HNO_3, precipitated as AgCl with HCl, collected in a Gooch crucible, washed, dried and weighed, the AgI in solution being calculated from the Ag found. The number of c.c. of the thiosulphate solution used was found from the weights by deducting weight of AgI and dividing by sp. gr. of this solution. In the later experiments the Ag was determined in the HNO_3 solution by means of Volhard's method.

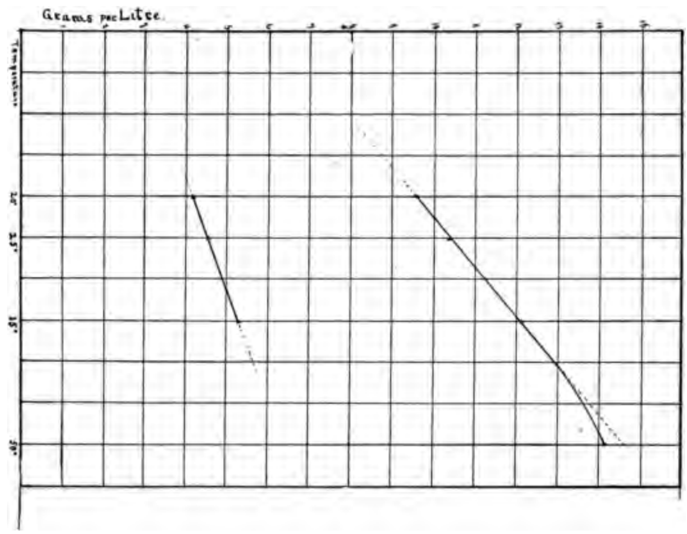
The agitator used was similar to that used by Richards and Faber based upon the Noyes' Apparatus, consisting of a wooden roller rotating in a large bath regulated by an Ostwald thermostat. The rubber stoppered tubes were strapped to the roller by means of rubber bands, the roller being driven by a small hot air engine.

The solubility of the silver iodide is shown by the following tabular statement, N and N/2 solutions being used.

Temp.	Time of Agitation.	$Na_2S_2O_35H_2O$ to 100 c.c. sol.	AgI dissolved to 100 c.c. sol.	Ratio AgI in mol's to 1 mol. $Na_2S_2O_35H_2O$.
20°	7 hours	24.83	.9613	.040945
25°	8 hours	24.83	1.0380	.044211
35°	8 hours	24.83	1.1870	.050558
50°	6 hours	24.83	1.4115	.060129
20°	6 hours	12.415	.4173	.035549
25°	6 hours	12.415	.4564	.038865
35°	7 hours	12.415	.5277	.044953

From the accompanying diagram the effect of temperature upon solubility is clearly seen, the amount of AgI dissolved increasing quite rapidly with the increase of temperature, and the solubility curve being practically a straight line. After standing some time the AgI in the tubes begins to blacken, probably caused by a slight decom-

position of the thiosulphate. This is noticeable at as low a temperature as 25°, and at 50° becomes very marked, which probably accounts for the failure of this point in the diagram to fall upon the straight line. Above 50° the decomposition is too great to permit the further determination of solubilities. That light does not affect the solubility of the AgI was shown by using, in two experiments, AgI made by red light, the agitation being carried out under the same condition.



A few experiments were tried to determine the effect of temperature on the solubility of Ag Br in thiosulphate solutions, and it was found that as much Ag Br was dissolved at 20° as at 35°. Thus it is seen that the solubility of the bromide does not increase with the temperature as is so markedly true in the case of the iodide. Cohen states in the case of the chloride that the full amount of Ag Cl will be found in solution only when an excess of the Ag Cl is avoided and there is just enough present to satisfy the equation.

$$3Na_2S_2O_3 + 2AgCl = (AgS_2O_3Na)_2Na_2S_2O_3 + 2NaCl.$$

This method was tried with both the AgI and Ag Br, the agitation being continued for several hours, but in neither case was as much silver found in the solution as when the

silver salt was in excess, showing that in these cases saturation was not obtained, and that the bromide and iodide did not unite with sodium thiosulphate in these experiments, in the proportion corresponding to the equations of Cohen.

In attempting to determine the solubility of silver iodate in sodium thiosulphate solution it was found that with strong thiosulphate solution and an excess of $AgIO_3$ a rather violent reaction occurred and much heat was evolved. It was found necessary then, to use a more dilute thiosulphate solution, so a N/10 solution was employed. By shaking this with a small excess of $AgIO_3$ until the first signs of reaction appeared, requiring 20 to 30 minutes, then by filtering off and weighing a portion of the solution and determining the silver an approximation at the amount of $AgIO_3$ dissolved was obtained.

100C.C. N/10 THIO. DISSOLVED $AgIO_3$ GRAMS.	GRAMS $AgIO_3$ PER GRAMS THIO.
4.26	1.176
4.97	2.002

Upon the molecular basis of iodide and iodate the $AgIO_3$ is about 16 times as soluble as the AgI.

The reaction just described between the $AgIO_3$ and $Na_2S_2O_3$ has not, so far as known to me, been described in the literature, and the nearest approach to it is that described by Landholdt* on the action of sulphur dioxide on iodic acid.

A preliminary experiment showed that with 1.5 molecules of thiosulphate to one molecule $AgIO_3$ there was no very apparent reaction, but when molecule for molecule was used practically all the $AgIO_3$ went into solution, that which remained blackened showing the formation of Ag_2S, then began the precipitation of AgI which continued until there was no more silver in solution. It was deemed best to study the reaction when the substances were put together in equal molecules. After shaking and allowing to stand for about forty-eight hours the solution was found to be acid, neither silver nor thiosulphate was found in the

* Berichte 19: 1317.

solution, no hydriodic acid was present, but a small quantity of iodic acid was found. A determination of the sulphuric acid in the solution and the amount of sulphur combined with the silver and in the free state accounted for all the S in the $Na_2S_2O_3$ used, showing complete decomposition of the thiosulphate. In a similar experiment, in which the substances were allowed to stand for about a week, the residue contained no silver sulphide, showing that the formation of Ag_2S is an intermediate reaction and that the reaction of the first experiment did not complete itself in the time allowed it.

For the determination of the products of the reaction the following methods were pursued. The residue was filtered off, washed, and the filtrate and washings made up to 100 c.c., portions of 20 c.c. being taken for analysis. The sulphates were precipitated by means of barium chloride and weighed as barium sulphate. To determine the iodic acid the solution was digested for several hours with 10 c.c. conc. HCl and KI in a closed bottle, the free iodine being then titrated with N/10 thiosulphate and the iodine found as HIO_3 calculated. The residue was dried at 110°, the free sulphur extracted by repeated treatment with hot chloroform, the chloroform evaporated and the sulphur weighed. The following results were obtained from the analysis of the completed reaction:

Weight of $AgIO_3$ taken	.4046g.
c.c. N/10 thiosulphate 14.31=$Na_2S_2O_3 5H_2O$	.3553g.
Weight of $BaSO_4$ .1124g., total S as sulphate	.07718g.
Free S in residue	.0178g.
Total sulphur found	.09498g.
Sulphur in thiosulphate taken	.09158g.
Total iodine in HIO_3 in filtrate	.03530g.
Iodine as HI	None.
Total iodine in $AgIO_3$ used	.1815g.
Hence iodine in residue	.1462g.

The iodine in the residue is in combination with silver as AgI, excepting the possibility of a very small quantity of $AgIO_3$ undecomposed in the reaction. There being no Ag in the solution, there must be more Ag in the residue

than will combine with the iodine, and which probably, then, exists as Ag_2O.

The starting of this reaction requires an excess of $AgIO_3$ and seems to be due to the formation of Ag_2S setting free acid. It might be accounted for by the occurrence of such a reaction as the following: $2AgIO_3 + Na_2S_2O_3 + H_2O = Ag_2S + 2HIO_3 + Na_2SO_4$. When the thiosulphate is in excess no reaction takes place, but on the addition of the slightest amount of free acid the reaction begins.

It is practically impossible to obtain even a close approximation of the solubility of silver bromate in thiosulphate because of the fact that the substances begin to react within ten minutes after they are put together, hence saturation could not be obtained. In a trial at this 100 c.c. N/10 thiosulphate solution disolved 1.835g. $AgBrO_3$.

For studying this reaction the $AgBrO_3$ and the $Na_2S_2O_3$ were put together molecule for molecule and after thorough shaking for several hours were allowed to stand for a week. Qualitative tests show that the solution contained no thiosulphate, no silver, a little bromic acid, sulphuric acid either free or as sulphate, and hydrobromic acid; the residue contains silver bromide, free sulphur, but no silver sulphide.

On analysis the following results were obtained, using the same methods as in the iodate reaction:

Weight of $AgBrO_3$ taken........................ .....6491g.
N/10 thiosulphate taken........................ ......27.52c.c.

Filtrate was made to 150 c.c. and 40 c.c. taken for each determination.

Weight $BaSO_4$ .3162g. Total S as sulphate.... ....16283g
Weight of free S in residue............ .... 0130g

Total sulphur found......... ....17583g
Total sulphur in $Na_2S_2O_3$ used.................17610g

Dried residue was treated with hot HNO_3 washed, dried and weighed as AgBr.

Weight of AgBr .3883g., weight Ag found.... ......22305g
Weight Br found..................................16525g

The Ag found in the filtrate from the AgBr was precipitated as AgCl by HCl and weighed in a Gooch crucible.

Weight of AgCl .0976g., weight of Ag found	.07347g.
Total silver found	.29652g.
Total silver in AgBr used	.29700g.
Weight of AgBr in 40 c.c., original filtrate	.0280g.
Weight of Br found as HBr	04468g.
Weight of Br found as $HBrO_3$	.0091g.
Weight of total bromine found	.21903g.
Weight of bromine in $AgBrO_3$ taken	.2200g.

From the above analysis there seems to be silver in the residue which cannot be in combination with either Br or S, and hence probably exists as Ag_2O, being undissolved by the very weak acid solution formed in the reaction.

There seems to be in general a similarity between the reactions of $AgIO_3$ and $AgBrO_3$ with sodium thiosulphate solutions. In both reactions the Ag_2S, which is at first formed, entirely disappears if the reaction be allowed to go to completion. The essential difference in the reactions seems to be the presence of HBr in the bromate reaction, while HI is absent from the iodate reaction, though a larger amount of HIO_3 is found in the latter than $HBrO_3$ in the former.

Chemical Laboratory of Iowa College, Grinnell, Iowa.

NEW METHOD OF COHESION OF WATER AND ADHESION OF MERCURY APPARATUS.

BY EDWIN MORRISON, PENN COLLEGE.

The difficulty of manipulating the ordinary apparatus in finding the cohesion of water and other liquids has thrown this beautiful and instructive laboratory experiment out of the reach of most students of Physics. Professor Nichols of Cornell University, says of this experiment: "The difficulties of controlling the conditions are so great, that the determination is one not to be recommended to the beginner." The first difficulty has been to accurately adjust the glass plate used in the experiment so that it will be parallel to the surface of the liquid to be tested; next, on account of the tension applied in separating the portion of the liquid tested the cords stretch, so that it is no longer parallel to the surface of the liquid, and one edge of the disk will come off from the water too soon, thus splitting the particles of the water a little at a time, instead of separating the water area equal to the cross section of the disk all at once.

The ordinary way of attaching the disk to one arm of a scale beam by means of pieces of cork glued to the glass, and guy cords is shown in fig. 1. The difficulties mentioned above can be entirely overcome, and the experiment rendered suitable for even elementary laboratory work by suspending the glass disk in the following way. Upon the lathe turn out a wooden cone which is about

one-half inch less in diameter than the glass disk. The cone should have an altitude of about six inches. The altitude depends somewhat upon the size of the scales used. The cone must be accurately turned and the base must be trued up while the piece is still in the lathe. Fasten the glass disk to the base of the cone by means of

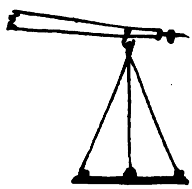


FIG. 1.

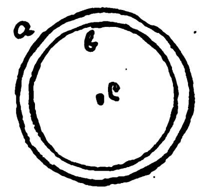


FIG. 2.

any good laboratory wax. I have found it to be the most satisfactory to use a wax that will melt at a low degree of heat. The glass can be heated to a degree sufficient to melt the wax over an asbestos pad placed upon a ring stand above a flame. As the wax melts flow it around evenly on the upper side of the disk, and set the base of the cone in it. To center the cone upon the disk previous to melting the wax a circle (a) fig. 2, the exact diameter of the glass disk should have been marked on a piece of paper. Using the same center (c) mark out another circle (b) having the same diameter as the base of the cone. Slip the paper under the glass disk on the asbestos pad, and place it so that the circumference just coincides with the circle (b). If the wax is not too thick and opaque the inner circle can be seen through the glass, and serves to locate the base of the cone so that it is equally distant from the circumference of the glass disk. A small hook can be accurately screwed into the apex of the cone for suspending it to the scale beam.

The glass disk should be made of plate glass not less than one-fourth inch in thickness, and if it is one-half inch it is all the better. The disk can be made by first cutting out a plate as nearly round as possible with a good glass cutter. Corners of glass can be broken off after cutting with the glass cutter by clamping between pieces of hard wood in a vice, and suddenly pushing the free part of the

Method of cone suspension in apparatus for finding the cohesion of water.

glass to one side. When as round as it is possible to cut it with a glass cutter fasten it to a small face plate of a lathe by means of little soft wax balls. A wooden face plate held in a chuck will serve the purpose. For the cutting instrument use a sheet-iron strip some two inches wide, and of a length a little more than the circumference of the disk when finished. Bend it into a circular form, and after having put emery paste on the inner side, hold it, by means of the hands, firmly around the circumference of the rapidly revolving disk. The emery paste is made by mixing emery powder with water. A course emery should be used at first, and the final cutting should be done with fine emery. The complete apparatus is shown in plate xv. The advantages of the cone suspension over the old methods are: first—it gives a rigid support, and if accurately constructed it will always hang parallel to the surface of the water, and the disk will come away from the water all at once instead of separating the water a little at a time. Second—the cone gives stability to the apparatus, which adds much to the accuracy as well as to ease of manipulation.

A CONVENIENT VOLTAIC CELL.

BY L. BEGEMAN.

I wish to discuss briefly a convenient form of the Lalande class of voltaic cells for which the government has recently allowed me a patent. While the cell possesses nothing startling in its newness, it yet has those advantages which make it better, I think, than any other for the purpose for which it was devised.

The old Lalande-Chaperon primary cell consisted of a steel jar with a sealed top from which was suspended a coiled rod of zinc. The electrolyte was either caustic soda or potash, and the depolarizer was copper oxide, a thick layer of which was placed in a copper pan resting on the bottom of the container. The cell was remarkable for its great capacity, but defective in that the depolarizer was not in firm contact with the positive electrode which resulted in a comparatively high internal resistance and a sluggish depolarization.

The well known Edison primary is a modified Lalande in which this defect is overcome by compressing the copper oxide into firm plates that serve both as depolarizer and positive electrode.

The Gordon is another familiar form of this class of cells. While it is true that the Edison and Gordon primaries are probably the best cells on the market for all purposes, yet their great cost almost prohibits them for general student use in the physical laboratory. Many experiments devised for students in secondary work demand a cell that delivers a constant current. The only primary cells that are capable of delivering a constant current for a period of time are those of the Lalande or Daniell class.

The Daniell cell, owing to its simple construction and low cost, is generally used for student purposes. All teachers of physics will agree with me, however, that the Daniell cell in the student's hands is the source of many exasperating accidents. The cell as usually mounted with porous jar practically destroys itself when accidently left on open circuit for a period of time. To prevent this the cell must be dismounted and again be reassembled at each new use. The zincs must be repeatedly amalgamated. The electrolytes in this process of dismounting and reassembling are spilled upon the laboratory tables. The glass jars are frequently broken producing chaos indescribable.

In order to avoid the great cost of the Lalande type of cells and also the exasperating incidents arising from the use of the Daniell, I undertook some two years ago to devise a cell cheap in cost and efficient in action. The result is the following cell sketched below and constructed as follows:

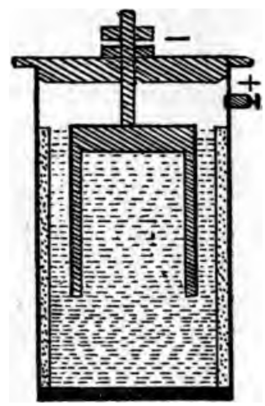


Fig: 1

The cell belongs to the Lalande class. It consists of a sheet steel container with double lapped seams. The seams are sealed by boiling into them a cement whose principal ingredients are old rubber and paraffine. This cement serves as a solder and prevents any leakage of the cell. The sides of the cell are either corrugated or plain and the interior is lined with a coil of netted elastic steel like ordinary window screen. Into the corrugations and the netted lining is firmly pressed the powdered copper oxide. To prevent the copper oxide from falling out its surface is lined with a piece of heavy muslin kept in its place by a piece of elastic steel netting. The bottom of the cell is finally covered with a thick layer of cement which prevents the copper oxide from leaking out from under the bottom of the lining. The sheet steel container with its netted linings and copper oxide constitute the positive pole electrode. The electrolyte is a thirty to forty

per cent solution of caustic soda or potash. Into the caustic soda is immersed the usual zinc electrode, suspended from the cover of the container.

The following comparative tests were made with the Edison, Gordon and the above described tin can cell.

The cells were placed successively in a closed circuit for a period of twenty-four hours. The external resistance of the circuit was .8 ohm. At stated intervals the internal resistance and E. M. F. of each cell were determined. The condenser method described on page 100, paragraph 55 of Carhart and Patterson Electrical Measurements was employed in these determinations. The apparatus used was a Rowland D'Arsonval galvanometer, a one-half microfarad condenser, a charge and discharge key, a resistance box and a standard Carhart-Clark cell. A diagram showing the connections of the apparatus will be found in Carhart and Patterson's work.

The E. M. F. of the Edison cell on closed circuit was .76 volts at the beginning. At the end of ten hours it reached .67 volts which it maintained during the entire run. It showed an initial internal resistance of .15 ohm which was reduced to its rated resistance of .05 ohm at the end of six hours at which it remained. The cell delivered a perfectly constant current of .8 ampere during the entire time. There were no observable changes in its E. M. F., resistance or current during the second twenty-four hours of its flow.

The E. M. F. of the Gordon cell sank at once to .7 volt at the beginning of the run and gradually lowered to .67 in three or four hours which it finally maintained. Its internal resistance at the beginning was .25 ohm which was gradually reduced to .08 ohm where it remained. The current was practically constant after the first four hours with a strength of .77 ampere.

The sheet steel cell started with an initial E. M. F. of .88 volts. It reached .76 volt at the end of four hours where it remained during the time of the test. Its initial internal resistance was .1 ohm which was reduced in a few hours to .05 ohm. After the first four hours the current reached .9

ampere and remained perfectly constant during the remaining time. This cell was allowed to run for three days longer. Its E. M. F. lowered slightly but was still .67 volt at the end of a four days' run. The cell delivered during that time about 80 ampere hours of electricity. At the end of four days its internal resistance was .04 ohm.

All three cells gave a voltage of .95 on open circuit before being used. All of them recovered to .8 volt inside of fifteen seconds when the circuit was broken after a twenty-four hour run. The Edison showed a higher efficiency than the Gordon. This, I think, is due to the fact that the copper oxide in the Gordon is rather loosely packed preventing as high a conductivity as the closely compressed plates of the Edison. The Edison was 150 ampere hour cell of the Q type and weighed seven and one-half pounds. The Gordon was the commercial 300 ampere hour cell and weighed fifteen pounds. The sheet steel cell was about the size of a pint measure and weighed about two and one-half pounds. Enough copper oxide was compressed into its netting to give it a capacity of 160 ampere hours for two discharges using the same zinc and but one renewal of the electrolyte.

The advantage of such a light sheet steel cell of high capacity is evident. It can be produced at less price than the Daniell. The container can not be broken. The lid can be sealed so as to prevent any spilling of the electrolyte. The cell is always ready for use. Local action in the cell is very small when the chemicals are comparatively pure. When working on low external resistance the wattage is always higher than that of a Daniell operating under similar conditions.

A very convenient thing about the cell, however, is its reversibility. When the capacity of the cell is exhausted as a primary, an amalgamated brass gauze electrode is substituted for storage purposes. When storing, the zinc is deposited on the amalgamated gauze and the reduced copper is converted into an oxide.

It is true that the two principal defects of the alkaline copper cell are first, that the zinc can not be deposited in

a firm coherent mass; and second, that the oxide of copper produced electrolytically slowly dissolves. I find, however, from experience, that these defects do not preclude the use of this class of storage cell for student laboratory work. In fact, I think they are much better than small lead cells. When the cell is not too highly charged, the zinc adheres quite firmly to an amalgamated brass electrode. Furthermore, when the sub-oxide of copper dissolves, it is probably at once reduced by the dense mesh of elastic steel netting which lines the can and which thus prevents it from affecting the deposited zinc. The result of the breaking down of the oxide, however, is to render the voltage unstable. A cell inactive for a period of time polarizes easily and its discharge efficiency is considerably impaired. Despite this, I find that a small-sized cell of this kind will give a better account of itself in continuous laboratory service than any lead cell of twice its weight.

FLORA OF EMMET COUNTY, IOWA.

BY R. I. CRATTY.

Emmet county lies in the northwestern part of the state, bordering on Minnesota, and has an area of 408 square miles. Its surface waters mostly find an outlet in the east and west forks of the Des Moines river, both of which flow through the county in a southeasterly direction. A small part of the northeastern township, near Iowa Lake, lies in the drainage area of the Minnesota river, and its flora, therefore, is represented in Prof. MacMillan's admirable volume, *The Metaspermæ of the Minnesota Valley.*

This county lies entirely within the area of the Wisconsin drift and the retreating ice fields of our last glacial period left within its borders many shallow depressions, the deeper of which have become permanent lakes; while the more shallow, which undoubtedly were once lakes and ponds, have been gradually filled by the erosive agency of wind and water, aided by the decaying vegetation of mosses and other aquatic plants, until at last the water-loving sedges and grasses gradually narrowed the shore line, till in most cases the whole was converted into a quaking bog; a few of which have an area of several hundred acres, while there are a great many of less size.

The greater part of the county has a gently rolling surface, there being no very high hills. The valleys of both branches of the Des Moines river are much below the level of the surrounding country, and show the effect of extensive erosion. In the eastern part of Iowa Lake and

Armstrong Grove townships, and occasionally elsewhere in the northern half of the county, are low ranges of morainic hills, which tend somewhat to relieve the otherwise monotonous landscape.

Drainage and cultivation are rapidly changing the marshes and, in some cases, even the lakes, into pastures and cultivable fields; and, therefore, the area once occupied by a hydrophytic vegetation is being greatly diminished.

There are comparatively few xerophytic plants in the county, and these usually occupy favorable localities along the river bluffs, or on the sterile, morainic hills. The flora of the woods and prairies resembles more closely that of the adjacent territory to the east and north; only a few typical western plants coming within our borders.

There are no rock exposures within our limits, and therefore the soil is unsuited for many of the ferns and other plants common to rocky woods. The forest area is small, being confined to the banks of the lakes and streams, but since the prairie fires have ceased, the wooded area shows a tendency to increase.

So large a proportion of the county consists of cultivable or pasture land, that very many of the indigenous species of plants must eventually become extinct within our area. Some few, already, can no longer be found, and it is with the view of recording the original flora, that this paper is prepared, as the author resided many years in the county when nine-tenths of its surface was covered by the virgin forest and prairie vegetation.

Compared with the area, the number of plants listed is small, only 590, including those introduced; but this may be accounted for, partly at least, by the slight diversity in surface and soil, and by the fact that it lies near the headwaters of its drainage streams, and is thus less favored by nature for seed distribution by natural agencies.

The climate of the county, like that of all portions of the northern Mississippi valley, is subject to great variation in temperature, the annual variation occasionally being as much as 140 degrees, the yearly mean being about 45 degrees. The annual precipitation, according to rather

fragmentary data is about 25 inches, and is usually so distributed as to be sufficient for agricultural operations, though in some seasons vegetation suffers from hot, southwest winds.

The synonomy adopted in the following catalogue is that of the *Illustrated Flora*, with such emendations as more recent publications make necessary. The names used in *Gray's Manual*, sixth edition, and the *Illustrated Flora* when different from those adopted in this list, are printed in parentheses.

The author takes pleasure in acknowledging valuable assistance in studying our native flora from numerous specialists in this and other states. Among those in our own state, whose aid has been freely given, are Prof. Thos. H. Macbride and Prof. B. Shimek of the Iowa State University; Prof. L. H. Pammel of the Iowa State College at Ames, and Prof. T. J. Fitzpatrick of Estherville, all of whom have published valuable papers treating different phases of the Iowa flora.

PTERIDOPHYTA.

POLYPODIACEÆ.

ONOCLEA L.

1. *O. sensibilis* L. Sensitive Fern. Rare in woods, Estherville; also introduced in an artificial grove in Armstrong Grove township.
2. *O. struthiopteris* (L.) Hoff. Ostrich Fern. Infrequent, Estherville and Armstrong Grove townships.

CYSTOPTERIS Bernh.

3. *C. fragilis* (L.) Bernh. Rare in woods throughout.

ASPLENIUM L.

4. *A. filix-fœmina* (L.) Bernh. Lady Fern. Woods, and occasionally in artificial groves; our most common species.

ADIANTUM L.

5. *A. pedatum* L. Maiden-hair Fern. Woods along West Fork of the Des Moines.

EQUISETACEÆ.

EQUISETUM L. Horse-tail, Scouring Rush.

6. *E. arvense* L. Very common in low ground.
7. *E. fluviatilis* L. (*E. limosum* L.) common in marshes; frequently much branched, especially the sterile stems.
8. *E. hyemale* L. Rare on dry banks.
9. *E. laevigatum*, A. Braun. Frequent on dry prairies.

SPERMATOPHYTA.

PINACEÆ.

JUNIPERUS L.

10. *J. virginiana* L. Red Cedar. High banks of lakes; becoming rare; our only native evergreen.

TYPHACEÆ.

TYPHA L.

11. *T. latifolia* L. Cat-tail Rush. Common throughout in marshes.

SPARGANIUM L.

12. *S. eurycarpum* Engelm Bur-reed. Frequent in marshes and along shores of ponds.
13. *S. simplex* Huds. Rare in marshes near Armstrong.

NAIADACEÆ.

POTAMOGETON L. Pond-weed.

14. *P. natans* L. West fork of the Des Moines river at Estherville. Also Spirit Lake, Dickenson county.
15. *P. amplifolius* Tuck. West Fork of Des Moines.
16. *P. lonchites* Tuck. Common, streams and lakes.
17. *P. heterophyllus* Schreb. Common in marshes throughout; a beautiful species.
18. *P. illinoense* Morong. Lake east of Armstrong, the station destroyed by the drying up of the lake. Part of the type material was from this locality.
19. *P. prælongus* Wulf. Rare; Iowa Lake.

20. *P. perfoliatus richardsonii* A. Bennett. (*P. perfoliatus lanceolatus* Robbins.) Common in lakes and quite variable; a most beautiful species.
21. *P. zosteræfolius* Schum. Iowa Lake.
22. *P. foliosus* Raf. (*P. pauciflorus* Pursh.) Common in lakes and slow streams.
23. *P. foliosus niagarensis* (Tuck.) Morong. Swift running water below mill-dam, Estherville, Aug. 7, 1897.
24. *P. friesii* Ruprecht. (*P. major* (Fries) Morong.) Iowa Lake, and probably in other lakes throughout the region.
25. *P. pectinatus* L. Very common in lakes throughout this and adjoining counties.

NAIAS L.

26. *N. flexilis* (Willd.) Rost & Schmidt. Common in shallow water in lakes.

SCHEUCHZERIACEÆ.

TRIGLOCHIN L.

27. *T. maritimum* L. Rare in marshes. Ours is the var *elatum* of Gray's Manual..

SCHEUCHZERIA L.

28. *S. palustris* L. Very rare; bog three miles northwest of Armstrong; the only known locality in the state.

ALISMACEÆ.

ALISMA L. Water-plantain.

29. *A. plantago-aquatica* L. Very common in low ground.

SAGITTARIA L. Arrow-head.

30. *S. latifolia* Willd. (*S. variabilis* Engelm.) Frequent throughout but much less common than the next.
31. *S. arifolia* Nutt. Very common in bogs and low places. This and the preceding species present great variation in leaf forms.

32. *S. cristata* Engelm. The type of this rare species was discovered in 1881, in a small lake, east of Armstrong. The station has since been destroyed but the plant occurs in several localities in Minnesota.

VALLISNERIACEÆ.

PHILOTRIA Raf. Ditch-moss.

33. *P. canadensis* (Michx.) Britton. Rare in rivers and lakes.

VALLISNERIA L. Eel-grass.

34. *A. spiralis* L. Rather frequent in lakes, but rarely seen in flower.

POACEÆ.

ANDROPOGON L. Beard-grass.

35. *A. scoparius.* Michx. Common on rather dry prairies.
36. *A. furcatus* Muhl. (*A provincialis* Gray's Man.) Crow-foot grass; very common; a valuable species for hay and pastures, but like most of our native grasses, quickly destroyed by close grazing.

SORGHASTRUM Nash.

37. *S. avenaceum* (Michx.) Nash. (*Chrysopogon avenaceus* Michx.) Benth. (*Sorghum nutans* Gray). Common on prairies with the preceding species.

SYNTHERISMA Walt.

38. *S. sanguinale* (L.) Nash. (*Panicum sanguinale* L.) A worthless European species introduced in cultivated and waste ground.
39. *S. linearis* (Krock.) Nash. (*Panicum glabrum* Gmelin.) Common; banks of lakes and streams.

ECHINOCHLOA Beauv. Barn-yard Grass.

40. *E. crus-galli* (L.) Beauv. (*Panicum crus-galli* L.) Introduced in cultivated and waste places.

PANICUM L.

41. *P. scribnerianum* Nash. (*Panicum panciflorum* A. Gray.) Dry prairies and knolls; common.
42. *P. dichotomum* L. Dry knolls; a hirsute form; infrequent.
43. *P. depauperatum* Muhl. Dry ground, woods and prairies; rare.
44. *P. virgatum* L. Very common.
45. *P. capillare* L. Very common, as well as useless.

CHÆTOCHLOA. Scribner. Fox-tail grass.

46. *C. glauca* (L.) Scribner. (*Ixophorus glaucus* (L.) Nash. *Setaria glauca* Beauv.) A very troublesome weed, introduced in cultivated fields.
47. *C. viridis* (L.) Scribner. (*Ixophorus viridis* (L.) Nash. *Setaria viridis* Beauv.) Introduced like the preceding, but less common.

ZIZANIA L. Wild Rice.

48. *Z. aquatica* L. Common in marshes. The seeds of this annual grass during very dry seasons will lie dormant, only germinating when the proper conditions of moisture exist.

HOMALOCENCHRUS Mieg.

49. *H. virginicus* (Willd.) Britton. (*Leerzia virginica* Willd.) Low places in woods; common.
50. *H. oryzoides* (L.) Poll. (*Leerzia oryzoides* Sav.) Common in marshes, and along streams.

PHALARIS L.

51. *P. arundinacea* L. Rare, near Armstrong.

SAVASTANA Schrank. Sweet vernal Grass.

52. *S. odorota* (L.) Scribner. (*Hierochloa borealis* R. and S.) Our earliest flowering grass; common in low ground, and quite difficult to subdue.

STIPA L.

53. *S. spartea* Trin. Porcupine Grass. Common in high prairies.

ORYZOPSIS Michx.

54. *O. melanocarpa* Muhl. Frequent in woods.

MUHLENBERGIA Schreb.

55. *M. mexicana* (L.) Trin. Common, woods and prairies.

56. *M. racemosa* (Michx.) B. S. P. (*Muhlenbergia glomerata* Trin.) Common and quite difficult to subdue in low ground.

PHLEUM L. Timothy.

57. *P. pratense* L. Escaped from cultivation.

ALOPECOURUS L. Marsh Fox-tail.

58. *A. fulvus* Smith. Rare in marshes; the common eastern species, *A. geniculatus* L. has not been detected within our limits.

SPOROBOLUS R. Brown. Rush-grass.

59. *S. neglectus* Nash. Very common in pastures, where it is utterly worthless, never being eaten by cattle.

60. *S. cuspidatus* (Torr.) Wood. A slender species, quite common on dry knolls.

61. *S. cryptandrus* (Torr.) A. Gray. Rare, east bank of Iowa lake, and bank of Des Moines at Estherville.

62. *S. heterolepis* A. Gray. A valuable bunch grass, common on high prairies; called wire-grass by haymakers, because the wirey culms when mature are difficult to cut with the mower.

CINNA L. Wood Reed-grass.

63. *C. arundinacea* L. Low ground in woods; Iowa Lake.

AGROSTIS L.

64. *A. alba* L. (*A. vulgaris* With.) Red-top. Naturalized from Europe.

65. *A. hyemalis* (Walt.) B. S. P. (*Agrostis scabra* Willd.) Hair-grass. Common on low prairies.

CALAMAGROSTIS Adans.

66. *C canadensis* (Michx.) Beauv. Common, and very variable.

67. *C. confinis* (Willd.) Nutt. Common on low prairies.

CALAMOVILFA Hack.

68. *C longifolia* (Hook.) Hack. (*Calamagrostis longifolia* Hook). Rare in dry ground; just south of state line on road to Iowa Lake from the south.

SPARTINA Schreb. Tall Slough-grass.

69. *S cynosuroides* (L.) Willd. Very common on low prairies, and one of our most valuable native grasses. The long white rhizomes are very numerous, and are difficult to cut with the plow.

BOUTELOUA Lag. Grama-grass.

70. *B oligostachya* (Nutt.) Torr. Rare; dry ground near Estherville.

ATHEROPOGON Muhl.

71. *A curtipendula* (Michx.) Fourn. (*Bouteloua curtipendula* Torr). Common on upland prairies.

PHRAGMITES Trin. Reed.

72. *P. phragmites* (L) Karst. (*P. communis* Trin). Our tallest species of grass, everywhere common in marshes.

ERAGROSTIS Beauv.

73. *E. frankii* Steud. Local; north shore of Iowa Lake.

74. *E. purshii* Schrad. Infrequent; shores of lakes and along roadsides where the seeds have probably been carried by the wheels of vehicles.

75. *E. major* Host. (*E. poœoides* var *megastachya* A. Gray.) Introduced in cultivated ground.

76. *E hypnoides* (Lam.) *B. S. P.* (*E. reptans* Nees.) Common on river banks.

EATONIA Raf.

77. *E obtusata* (Michx.) A. Gray. Common on dry prairies.

78. *E. pennsylvanica* (D. C.) A. Gray. Common in low ground and marshes.

79. *E. pennsylvanica major* Torr. Infrequent in low places.

KOELERIA Pers.

80. *K. cristata* (L.) Pers. Very common on high prairies.

POA L.

81. *P. compressa* L. Infrequent, woods and prairies.
82. *P. pratensis* L. Kentucky Blue-grass. Everywhere along roadside, but not native to this region.
83. *P. flava* L. (*P. serotina* Ehrh.) Frequent, woods and prairies.
84. *P. sylvestris* A. Gray. Frequent in woods.

SCOLOCHLOA Link.

85. *S. festucacea.* (Willd.) Link. *Graphephorum festucaceum* A. Gray. Frequent in marshes. This is the southern limit of the species in the United States so far as known.

PANICULARIA Fabr.

86. *P. nervata.* (Willd.) Kuntze. (*Glyceria nervata* Trin.) Low woods and prairies; common.
87. *P. americana.* (Torr.) Mac M. (*Glyceria grandis* Watson.) A robust species common in marshes.
88. *P. fluitans* L. Kuntze. (*Glyceria fluitans* L.) Common in marshes.

FESTUCA L.

89. *F. nutans* (Willd.) Low woods, Estherville and Iowa Lake.

BROMUS L.

90. *B. ciliatus* L. Common in woods and very variable.
91. *B. secalinus* L. Chess, Cheat. Becoming quite common; introduced from Europe into wheatfields.

AGROPYRON J. Gaertn.

92. *A. occidentale* Scribner. (*Agropyrum spicatum* Scrib. & Smith.) Common on dry prairies; a very good pasture grass.
93. *A. tenerum* Vasey. Woods and prairies; common.
94. *A. caninum* (L) R. and S. (*Agropyrum unilaterale* Vasey.) Rare on dry praries.

HORDEUM L.

95. *H. jubatum* L. Wild Barley. A troublesome weed, everywhere common.

ELYMUS L. Wild Rye.

96. *E. striatus* Willd. Frequent in woods.

97. *E. virginicus* L. Frequent in woods, and on river banks.

98. *E. canadensis* L. Common, and extremely variable.

HYSTRIX Mœnch.

99. *H. hystrix* (L.) Millsp. (*Elymus hystrix* L.) Common in woods.

CYPERACEÆ.

CYPERUS L.

100. *C. rivularis* Kunth. (*C. diandrus* var *castaneus* Torr.) Very common and variable; banks of lakes and rivers.

101. *C. inflexus* Muhl. (*C. aristatus* Bœckl.) Common; banks of lakes and streams.

102. *C. schweinitzii* Torr. North shore of Swan Lake; also at Spirit Lake, Dickinson county.

103. *C. erythrorhizos* Muhl. Banks of lakes and streams; our handsomest species.

104. *C. speciosa* Vahl. Banks of lakes and streams, and in marshes; very variable.

105. *C. strigosus* L. Less common than the preceding and in similar situations; variable.

106. *C. strigosus capitatus* Bœckl. Very distinct in appearance, but undoubtedly merely a state produced by very dry weather. Rare; slough one mile northeast of Armstrong.

ELEOCHARIS R. Brown.

107. *E. palustris* (L.) R. & S. Common in marshes and variable.

108. *E. palustris glaucescens* (Willd.) Gray. Very common in low ground.

109. *E. acicularis* (L.) R. & S. Everywhere in low marshy places.

110. *E. wolfii* Gray. Rare; low prairies near Armstrong.

SCIRPUS L.

111. *S. lacustris* L. (*S. validus* Vahl.) Great Bulrush. Very common in marshes, shallow lakes and along streams.

112. *S. fluviatilis* (Torr.) A. Gray. Frequent in marshes; our largest fruited species.

113. *S. atrovirens* Muhl. Low prairies, common.

ERIOPHORUM L. Cotton-grass.

114. *E. polystachyon* L. Marshes and low prairies.

115. *E. gracile* Koch. Rare in marshes. Our plant is the form called var. *paucinervium* by Engelman.

CAREX L. Sedge.

116. *C. lupulina* Muhl. Low ground, Iowa Lake; rare.

117. *C. monile* Tuck. Rare in low ground, Armstrong.

118. *C. retrorsa* Schwein. Rare in woods; Estherville and Iowa Lake.

119. *C. hystricina* L. Infrequent; Estherville and Spirit Lake.

120. *C. comosa* Boott. Marshes; Armstrong.

121. *C. trichocarpa* Muhl. Ravines west of Estherville.

122. *C. aristata* R. Br. Rare; marsh one mile east of Armstrong.

123. *C. riparia* W. Curtis. Frequent in marshes.

124. *C. lanuginosa* Michx. (C. *filiformis* var. *latifolia* Bœckl.) Frequent in low ground.

125. *C. filiformis* L. Common in bogs; one of the principal plants which help to form the tough, floating sod in the quaking marshes.

126. *C. fusca* All. (C. *buxbaumii* Ten.) Rare; in swamps near Armstrong.

127. *C. stricta angustata* (Boott.) Bailey. Infrequent; shores of streams and lakes and occasionally in marshes; variable.

128. *C. limosa* L. Rare; in marshes in Armstrong Grove township.

129. *C. longirostris* Torr. Common in woods. A very distinct species.

130. *C. amphibola* Steud. (*C. grisea* var. *angustifolia* Boott.) Rare; woods west of Estherville.

131. *C. crawei* Dewey. A pretty little plant, but very rare in Iowa; N. E. corner, sec. 11, T. 99 N., R. 31 W., one and one-half miles northeast of Armstrong.

132. *C. grisea* Wahl. Rare in woods, south shore of Iowa lake.

133. *C. meadii* Dewey. Very common on low prairies.

134. *C. laxiflora blanda* (Dew.) Boott. Frequent in woods.

135. *C. setifolia* (Dew.) Britton. (*C. eburnea* Boott.) Rare; dry hillsides in woods.

136. *C. pennsylvanica* Lam. Very common on upland prairies. Our earliest sedge.

137. *C. chordorhiza* L. f. Bog two and one-half miles north of Armstrong. A common high northern species barely coming within our limits. The only known station in the state.

138. *C. stenophylla* Wahl. Rare; dry ground; schoolhouse block, Estherville. The station since destroyed. The only other known locality in the state is in Lyon county (Prof. Shimek.)

139. *C. stipata* Muhl. Common near water in low woods.

140. *C. teretiuscula* Gooden. Frequent in marshes.

140. *C. teretiuscula prairea* Dewey. Bogs; more common than the species.

141. *C. gravida* Bailey. Very common in woods, and occasionally on open prairies.

142. *C. vulpinoidea* Michx. Very common in low ground.

143. *C. sartwellii* Dewey. Infrequent on low prairies. Usually diœcious.

144. *C. rosea* Schkuhr. Frequent, woods and prairies.

145. *C. rosea radiata* Dewey. Rare in dry woods.

146. *C. interior* Bailey. Woods and prairies. Usually growing in dense tufts.

147. *C. tribuloides bebbii* (Olney Baily.) Infrequent in marshes.

148. *C. cristatella* Britton. (*C. cristata*) Schwein. Frequent in low woods.
149. *C. straminea* Willd. Rare in woods.
150. *C. festucacea* Willd. (*C. straminea brevior* Dewey.) Common, and extremely variable.
151. *C. bicknellii* Britton. (*C. straminea* var. *crawei* Boott.) Common on upland prairies.
152. *C. sychnocephala* Carey. Rare in a marsh east of Armstrong; also at Spirit Lake. A plant very different in appearance from any other American species of the genus.

ARACEÆ.

ARISÆMA Mart.

153. *A. triphyllum* (L.) Torr. Jack-in-the-pulpit; Indian Turnip. Frequent in rich woods.

ACORUS L.

154. *A. calamus* L. Sweet-flag; calamus-root. Infrequent in marshes.

LEMNACEÆ.

SPIRODELA Schleid.

155. *S. polyrhiza* (L.) Schleid. (*Lemna polyrhiza* L.) Very common, floating on stagnant water, especially in bayous along streams.

LEMNA L.

156. *L. trisulca* L. Ponds and marshes; frequent.

COMMELINACEÆ.

TRADESCANTIA L.

157. *T. virginiana* L. Spiderwort. Open woods and prairies; common.

PONTEDERIACEÆ.

HETERANTHERA R. & P.

158. *H. dubia* (Jacq.) Mac M. (*Schollera graminea* A. Gray.) Infrequent; shores of lakes.

JUNCACEÆ.

JUNCUS L. Rush.

159. *J. balticus* Deth. Very rare; saline soil; Armstrong.

160. *J. tenuis* Willd. Very common on low prairies.

161. *J. nodosus* L. Infrequent; in low places.

162. *J. torreyi* Coville. (*J. nodosus* var. *megacephalus* Torr.) Frequent in low ground.

JUNCOIDES Adans.

163. *J. campestre* (L) Kuntze. (*Luzula campestre* D C.) Rare, woods west of Estherville.

MELANTHACEÆ.

ZYGADENUS Michx.

164. *Z. elegans* Pursh. (*Z. glaucus* Nutt.) Very common on prairies.

UVULARIA L. Bellwort.

165. *U. grandiflora* J. E. Smith. Frequent in rich woods.

LILIACEÆ.

ALLIUM L. Wild Onion. Leek.

166. *A. tricoccum* Ait. Rare, woods near Estherville.

167. *A. cernuum* Roth. Common on prairies.

168. *A. canadense* Kahn. Frequent on low prairies.

LILIUM L.

169. *L. philadelphicum* L. Red Lily. Common on prairies.

170. *L. superbum* L. Turk's-cap Lily. Rare near Estherville (James Espeset).

ERYTHRONIUM L.

171. *E. albidum* Nutt. White Adder's-tongue. Frequent in woods.

CONVALLARIACEÆ.

ASPARAGUS L.

172. *A. officinalis* L. Asparagus. A common species escaped from cultivation.

VAGNERA Adans.

173. *V. racemosa* (L.) Morong. (*Smilacina racemosa.* Desf.) Common in the woods.

174. *V. stellata* (L.) Morong. (*Smilacina stellata* Desf.) Common in woods.

POLYGONATUM Adans.

175. *P. commutatum* (R. & S.) Diet. (*P. giganteum* Diet.) Frequent in low woods.

TRILLIUM L. Wake-robin.

176. *T. nivale* Riddell. Very rare in the woods north of Estherville.

177. *T. erectum* L. Rare in woods; Iowa Lake, and Armstrong Grove. Our form always has declined flowers.

SMILACEÆ.

SMILAX L. Smilax; Green-brier.

178. *S. herbacea* L. Common in woods.

179. *S. hispida* Muhl. Frequent in woods.

AMARYLLIDACEÆ.

HYPOXIS L. Star-grass.

180. *H. hirsuta* (L.) Coville. (*H. erecta* L.) Very common on low prairies.

IRIDACEÆ.

IRIS L. Blue Flag.

181. *I. versicolor* L. Common in low ground and marshes.

SISYRINCHIUM L. Blue-eyed Grass.

182. *S. angustifolium* Mill. Very common on low prairies.

ORCHIDACEÆ.

CYPRIPEDIUM L.

183. *C. candidum* Willd. Small White Lady-slipper. Frequent on low prairies.

184. *C. hirsutum* Mill. (*C. pubescens* Willd.) Large Yellow Lady-slipper. Rare in woods west of Estherville.

HABENARIA Willd. Rein Orchis.

185. *H. leucophæa* (Nutt.) A. Gray. Frequent on low prairies.

GYROSTACHYS Pers.

186. *G. cernua* (L.) Kuntze. (*Spiranthes cernua* L. C. Richards.) Very rare on low prairies.

LEPTORCHIS Thouars.

187. *L. lœselii* (L.) Mac M. (*Liparis lœselii* L. C. Richards.) Very rare; artificial grove, one and one-half miles northeast of Armstrong, where it was probably introduced by the birds. It is not known from any other locality in the state.

JUGLANDACEÆ.

JUGLANS L.

188. *J. nigra* L. Black Walnut. This valuable tree once quite common along streams, is becoming rare.

HICORIA Raf.

189. *H. minima* (Marsh.) Britton. (*Carya amara* Nutt.) Bitter-nut. Frequent in woods; our only hickory.

SALICACEÆ.

POPULUS L.

190. *P. alba* L. White or Silver-leaf Poplar. Escaped from cultivation; the tree, although a handsome one, can not be recommended, as it spreads badly by the roots.

191. *P. tremuloides* Michx. American Aspen. Infrequent in woods; rarely in clumps on the prairie.

192. *P. deltoides* Marsh. (*P. monilifera* Ait.) Cottonwood. Rare in the native state in several localities in the county, but becoming very common in cultivation and as an escape in low ground.

SALIX L.

193. *S. nigra* Marsh. Black Willow. Frequent along streams.

194. *S. amygdaloides* Anders. Peach-leaved Willow. Common throughout, near lakes and streams.

195. *S. alba vitellina* (L.) Koch. White Willow. This European form is commonly cultivated throughout this region, and is frequent as an escape.

196. *S. fluviatilis* Nutt. (*S. longifolia* Muhl.) Sand-bar Willow. One of our most common species.

197. *S. humilis* Marsh. A pretty little shrub, rare in the border of woods, and on the prairies.

198. *S. discolor* Marsh. Pussy Willow. A pretty shrub, or low tree; frequent in low ground.

199. *S. cordata* Muhl. Heart-leaved Willow. Very common along streams, and on low prairies.

200. *S. myrtilloides* L. Bog Willow. This northern species, from one to three feet high, occurs in a bog two miles north of Armstrong, the only locality known in the state.

BETULACEÆ.

OSTRYA Scop.

201. *O. virginiana* (Mill.) Willd. Hop Hornbeam, Iron-wood. A small tree common in woods.

CORYLUS L.

202. *C. americana* Walt. Hazel-nut. Frequent on the edges of woods, but much less common than farther east.

FAGACEÆ.

QUERCUS L.

203. *Q. rubra* L. Red Oak. Common in the woods in the western part of the county.

204. *Q. macrocarpa* Michx. Bur Oak. Our commonest native tree; a species which exhibits the pioneer spirit, reaching out into the prairies in advance of any other of the hard wood trees.

ULMACEÆ.

ULMUS L.

205. *U. americana* L. White or Water Elm. Common along streams; one of our most desirable shade trees.

206. *U. fulva* Michx. Slippery Elm. Frequent.

CELTIS L.

207. *C. occidentalis* L. Hackberry. Rather rare.

MORACEÆ.

CANNABIS L.

208. *C. sativa* L. Hemp. A native of Europe and Asia, escaped from cultivation.

URTICACEÆ.

URTICA L.

209. *U. gracilis* Ait. Nettle. Common in woods, and introduced into rich ground near dwellings, where it is a troublesome weed.

URTICASTRUM Fabr.

210. *U. divaricatum* (L) Kuntze. (*Laportea canadensis* Gaud.) Common in woods.

ADICEA Raf.

211. *A. pumila* (L.) Raf. (*Pilea pumila* Gray.) Common in low woods.

PARIETARIA L.

212. *P. pennsylvanica* Muhl. Infrequent, south shore of Iowa Lake.

SANTALACEÆ.

COMANDRA Nutt.

213. *C. umbellata* (L.) Nutt. Common on prairies.

ARISTOLOCHIACEÆ.

ASARUM L.

214. *A. canadense* L. Wild Ginger. Rare in woods west of Estherville.

POLYGONACEÆ.

RUMEX L.

215. *R. altissimus* Wood. Peach-leaved Dock. Common in low ground.

216. *R. britannica* L. Great Water-Dock. Frequent; borders of ponds, and along streams.

217. *R. crispus* L. Curled Dock. An European species, introduced into cultivated fields.

218. *R. persicarioides* L. (non *R. maritimus* L.) Common in marshes.

POLYGONUM L.

219. *P. amphibium* L. Ponds and sloughs; frequent, the large leaves floating in the water.

220. *P. hartwrightii* A. Gray. Very common in bogs, but rarely seen in flower or fruit.

221. *P. emersum* (Michx.) Britton. (*P. muhlenbergii* Watson.) Very common in sloughs and low ground.

221. *P. incarnatum* Ell. Common, especially in cultivated ground, or near dwellings.

222. *P. pennsylvanicum* L. Everywhere common.

223. *P. punctatum* Ell. (*P. acre* H. B. K. non Lam.) Water Smart-weed. Common in low, wet ground.

.224. *P. aviculare* L. Knot-grass, Door-weed. Everywhere around dwellings.

225. *P. erectum* L. Rather rare near dwellings. Neither this nor the preceding species is probably native to our county, though indigenous to North America.

226. *P. ramosissimum* Michx. Common.

227. *P. convolvulus* L. Black Bind-weed. A troublesome European species, everywhere common in cultivated fields.

228. *P. scandens* L. Climbing False Buckwheat. Common in woods, where it climbs high over bushes.

CHENOPODIACEÆ.

CHENOPODIUM L.

229. *C. album* L. Lamb's-quarters, Pigweed. A common weed, naturalized from Europe.
230. *C. boscianum* Moq. Goosefoot. Common in woods.
231. *C. hybridum* L. Maple-leaved Goosefoot. Woods, Iowa lake, and probably elsewhere in the country.

SALSOLA L.

232. *S. tragus* L. (*S. kali* var. *tragus* Moq.) Russian Thistle. A noxious European weed, very common and troublesome in dry years.

AMARANTHACEÆ.

AMARANTHUS L.

233. *A. retroflexus* L. Pig-weed. A very common weed, naturalized from tropical America.
234. *A. blitoides* S. Watson. A common weed around dwellings, naturalized from the western plains.
235. *A. græcizans* L. (*A. albus* L.) Our commonest tumble-weed, introduced from tropical America.

ACNIDA L.

236. *A. tamariscina* (Nutt.) Wood. Frequent along streams, and in low cultivated ground—occasionally in marshes; on muskrat houses.

NYCTAGINACEÆ.

ALLIONIA Loefl.

237. *A nyctaginea* Michx. (*Oxybaphus nyctagineus* Sweet.) Frequent on knolls and in cultivated fields.
238. *A. hirsuta* Pursh. (*Oxybaphus hirsutus* Sweet.) Rare; dry ground along road south of Iowa Lake.

PORTULACACEÆ.

PORTULACA L.

239. *P. oleracea* L. Purslane. A fleshy weed, very common in cultivated ground, where it has become naturalized from its native home in the southwest, and tropical America.

CARYOPHYLLACEÆ.

AGROSTEMMA L.

240. *A. githago* L. (*Lychnis githago* Scop.) Corn Cockle. An European plant, adventive in wheat fields.

SILENE L.

241. *S. stellata* (L.) Ait. Starry Campion. Common in woods.

242. *S. antirrhina* L. Frequent in woods and waste places.

243. *S. noctiflora* L. Introduced into waste places, Estherville.

VACCARIA Medic. Cow-herb.

244. *V. vaccaria* (L.) Britton. (*Saponaria vaccaria* L.; *Vaccaria vulgaris* Host.) A common European weed, adventive in wheatfields.

ALSINE L.

245. *A. longifolia* (Muhl.) Britton. (*Stellaria longifolia* Muhl.) Common in marshes.

NYMPHÆACEÆ.

NYMPHÆA L.

246. *N. advena* Soland. (*Nuphar advena* R. Br.) Yellow Pond-lily. Common in lakes and ponds.

CASTALIA Salisb.

247. *C. tuberosa* (Paine) Greene. (*Nymphæa tuberosa* Paine.) White Pond-lily. Once very common in lakes and ponds, but becoming rare.

RANUNCULACEÆ.

CALTHA L.

248. *C. palustris* L. Marsh Marigold. Rare; found only in a marshy spring in the woods north of Estherville.

ISOPYRUM L.

219. *I. biternatum* (Raf.) Torr. and Gray. Common in woods.

ACTÆA L. Bane-berry.

250. *A. rubra* (Ait.) Willd. (*A. spicata* var. *rubra* Ait.) Frequent in Woods.

251. *A. alba* (L.) Mill. Frequent in low woods.

AQUILEGIA L. Columbine.

252. *A. canadensis* L. Common in woods.

DELPHINIUM L. Wild Lark-spur.

253. *D. carolinianum* Walt. (*D. azureum* Michx.) Common on prairies, especially on gopher knolls.

ANEMONE L.

254. *A. cylindrica* Gray. Frequent; woods and prairies.

255. *A. virginiana* L. Rare; in woods and thickets.

256. *A. canadensis* L. (*A. pennsylvanica* L.) Anemone. Very common; woods and prairies.

HEPATICA Scop. Liver-leaf.

257. *H. acuta* (Pursh.) Britton. Frequent in the woods along the West Fork of the Des Moines.

PULSATILLA Adans. Wind-flower.

258. *P. hirsutissima* (Pursh.) Britton. (*Anemone patens* L. var. *nuttalliana* Gray.) Very common on high prairies.

CLEMATIS L.

259. *C. virginiana* L. Virgin's Bower. Rare; in woods west of Estherville. (Mrs. J. W. Harrison.)

RANUNCULUS L. Crowfoot.

260. *R. delphinifolius* Torr. (*R. multifidus* Pursh.) Common in marshes.

261. *R. ovalis* Raf. (*R. rhomboideus* Goldie.) Frequent in earliest spring on dry slopes.

262. *R. abortivus* L. A homely species, very common in woods.

263. *R. sceleratus* L. Frequent near ponds and streams. The plant has an acrid taste.

264. *R. pennsylvanicus* L. Frequent in woods.

265. *R. septentrionalis* Poir. Very common on low prairies; a variable plant.

BATRACHIUM S. F. Gray.

266. *B. divaricatum* (Schrank) Wimm. (*Ranunculus circinatus* Sibth.) Very rare; in a pond along old C. M. & St. P. R. R., Estherville.

OXYGRAPHIS Bunge.

267. *O. cymbalaria* (Pursh) Prantl. (*Ranunculus cymbalaria* Pursh.) Frequent on low prairies.

THALICTRUM L.

268. *T. purpurascens* L. Meadow-rue. Woods and prairies; very common.

BERBERIDACEÆ.

CAULOPHYLLUM Michx.

269. *C. thalictroides* (L.) Michx. Blue Cohosh. Rare; woods west of Estherville.

MENISPERMACEÆ.

MENISPERNUM L.

270. *M. canadense* L. Moonseed. Frequent in woods.

PAPAVERACEÆ.

SANGUINARIA L.

271. *S. canadensis* L. Bloodroot. Common in woods.

BICUCULLA Adans. Dutchman's Breeches.

272. *B. cucullaria* (L.) Millsp. (*Dicentra cucullaria* Torr.) Low woods; common.

CAPNOIDES Adans.

373. *C. micranthum* (Engelm.) Britton. (*Corydalis micrantha* Engelm.) Rare in dry soil; Estherville and Iowa Lake.

CRUCIFERÆ.

LEPIDIUM L. Pepper-grass.

274. *L. virginicum* L. Waste places; less frequent than the next.

275. *L. apetalum* Willd. Very common, fields and roadsides.

SISYMBRIUM L.

276. *S. officinale* (L.) Scopoli. A common weed, naturalized from Europe.

BRASSICA L.

277. *B. nigra* (L.) Koch. Black Mustard. Waste places; less common than the next. Introduced from Europe.

278. *B. arvensis* (L.) B. S. P. (*B. sinapistrum* Boiss.) Charlock. Introduced from Europe into grain fields, where it is very common and troublesome.

RORIPA Scop.

279. *R. palustris* (L.) Bess. (*Nasturtium palustre* D C.) Common in low fields and swamps; the pods variable in shape.

280. *R. armoracia* (L.) A. S. Hitchcock. (*Nasturtium armoracia* Fries.) Horse-radish. An occasional escape from cultivation; a native of Europe.

CARDAMINE L.

281. *C. parviflora* L. (*C. hirsuta* var. *sylvatica* Gray.) Frequent in woods, Iowa Lake.

282. *C. bulbosa* (Schreb.) B. S. P. (*C. rhomboidea* D C.) Frequent along water courses.

DENTARIA L.

283. *D. laciniata* Muhl. Pepper-root. Frequent in rich woods.

BURSA Webber. Shepherds' Purse.

284. *B. bursa-pastoris* (L.) Britton. (*Capsella bursa-pastoris* Medic.) Naturalized from Europe; very common.

CAMELINA Crantz.

285. *C. sativa* (L.) Crantz. False Flax. Adventive from Europe in flax fields.

SOPHIA Adans.

286. *S. pinnata* (Walt.) Britton. (*Sisymbrium canescens* Nutt.) Rare on dry prairies.

ARABIS L.

287. *A. dentata* Torr. & Gray. Rare in woods, Iowa Lake.

288. *A. hirsuta* (L.) Scop. Rare in woods, Estherville.

289. *A. brachycarpa* (Torr. & Gray) Britton. (*A. confinis* S. Watson; *A. drummondii* Gray.) Common in dry woods.

ERYSIMUM L.

290. *E. cheiranthoides* L. Worm-seed. Common in woods.

CAPPARIDACEÆ.

POLANISIA Raf.

291. *P. trachysperma* Torr. & Gray. Common along shores of lakes, growing in sand. The plant has a strong, offensive odor.

CRASSULACEÆ.

PENTHORUM L.

292. *P. sedoides* L. Common in low ground and marshes.

SAXIFRAGACEÆ.

HEUCHERA L.

293. *H. hispida* Pursh. Dry prairies; infrequent.

PARNASSIA L. Grass of Parnassus.

294. *P. caroliniana* Michx. A very pretty plant, once common on low prairies, but rapidly disappearing.

GROSSULARIACEÆ.

RIBES L.

295. *R. cynosbati* L. Prickly Gooseberry. Infrequent in woods.

296. *R. gracile* Michx. Smooth-fruited Gooseberry. Very common in woods. The fruit sometimes sold in the market.

297. *R. floridum* L'Her. Wild Black Currant. Very common in woods. The fruit, resembling the black currant of the garden in flavor, is liked by some people.

ROSACEÆ.

SPIRÆA L. Meadow-sweet.

298. *S. salicifolia* L. A pretty little shrub, common in woods, and low prairies.

RUBUS L.

299. *R. strigosus* Michx. Wild Red Raspberry. Frequent in woods.

300. *R. occidentalis* L. Black Raspberry. Very common in woods, and introduced by birds into artificial groves. The original of the blackcap of the garden.

301. *R. villosus* Ait. Blackberry. Rare, in a ravine west of Estherville.

FRAGARIA L. Strawberry.

302. *F. virginiana* Duchesne. (*F. virginiana* var. *illinoensis* Prince). Very common on the prairies.

303. *F. vesca* L. Rather rare in woods.

POTENTILLA L.

304. *P. arguta* Pursh. Frequent on dry prairies.

305. *P. monspeliensis* L. (*P. norvegica* L.) Common, shores of lakes and streams, and in cultivated fields.

306. *P. paradoxa* Nutt. (non *P. supina* L.) Frequent on the shores of lakes.

307. *P. canadensis* L. Very rare; collected but once southeast of Armstrong.

COMARUM L.

308. *C. palustre* L. (*Potentilla palustris* Scop.) Marsh Five-finger. Rare in bogs in the eastern half of the county.

GEUM L.

309. *G. canadense* Jacq. (*G. album* Gmelin) White Avens. Frequent in woods.

AGRIMONIA L.

310. *A. hirsuta* (Muhl.) Bicknell. (non *A. eupatoria* L.) Common in woods.

ROSA L. Wild Rose.

311. *R. blanda* Ait. Common in woods. Leaflets 3 to 5; prickles few.

312. *R. arkansana* Porter. Very common on prairies. Very prickly; leaflets 5 to 9.

POMACEÆ.

MALUS Juss. Wild Crab-apple.

313. *M. ioensis* (Wood) Britton. (*Pyrus ioensis* Bailey.) Rare in woods.

AMELANCHIER Medic. June Berry.

314. *A. alnifolia* Nutt. Frequent in woods. A western species rarely found in this region.

CRATÆGUS L. Thorn Apple.

315. *C. punctata* Jacq. Rare in woods near Iowa Lake.

316. *C. coccinea* L. Our most common species.

317. *C. mollis* (Torr. and Gray.) Scheele. (*C. subvillosa* Schrad.) Frequent in timber. Our thorn apples are much confused and perhaps include several of the recently published species.

DRUPACEÆ.

PRUNUS L.

318. *P. americana* Marsh. Wild Plum. Very common in open woods.

319. *P. virginiana* L. Choke Cherry. Very common in open woods.

320. *P. serotina* Ehrh. Wild Black Cherry. Rare in woods west of Estherville.

CÆSALPINACEÆ

CASSIA L. Sensitive Pea.

321. *C. chamæcrista* L. Common in dry sandy soil. Sometimes cultivated.

PAPILIONACEÆ.

BAPTISIA Vent. Wild Indigo.

322. *B. bracteata* Ell. (*B. leucophæa* Nutt.) Common; prairies and border of woods.

MELILOTUS Juss.

323. *M. alba* Desv. White Sweet-clover. Frequent; adventive from Europe.

324. *M. officinalis* (L.) Lam. Yellow Sweet-clover. Infrequent; streets of Estherville. Adventive from Europe.

TRIFOLIUM L.

325. *T. pratense* L. Red Clover. Roadsides; escaped from cultivation.
326. *T. hybridum* L. Alsike Clover. Rare; introduced along road northeast of Armstrong, 1885.
327. *T. repens* L. White Clover. A very common escape from cultivation.

PSORALEA L.

328. *P. argophylla* Pursh. Very common on prairie slopes. Flowering freely, but rarely perfecting seed.
329. *P. esculenta* Pursh. Pomme de Prairie. Frequent on high prairies. The large starchy roots were used as an article of food by the Indians, and by the French voyageurs.

AMORPHA L.

330. *A. fruticosa* L. False Indigo. A common shrub on prairies and in open woods.
331. *A. nana* Nutt. (*A. microphylla* Pursh.) Frequent on prairies. A pretty little shrub, somewhat resembling box.
332. *A. canescens* Pursh. Lead Plant. Shoestring. A very common little shrub on prairies and borders of woods.

KUHNISTERA Lam.

333. *K. candida* (Willd.) Kuntze. (*Petalostemon candidus* Michx.) White Prairie Clover. Common.
334. *K. purpurea* (Vent.) Mac M. (*Petalostemon violaceus* Michx.) Purple Prairie Clover. Very common on prairies.

ROBINIA L.

335. *R. pseudacacia* L. Locust Tree. Rare, escaped from cultivation.

ASTRAGALUS L.

336. *A. crassicarpus* Nutt. (*A. caryocarpus* Ker.) Ground Plum. An early flowering species, common on dry prairies.

337. *A. carolinianus* L. (*A. canadensis* L.) Woods and prairies; common.

GLYCYRRHIZA L.

338. *G. lepidota* Pursh. Wild Licorice. Frequent on dry prairies.

MEIBOMIA Adans.

339. *M. canadensis* (L.) Kuntze. (*Desmodium canadense* D C.) Tick-trefoil. Open woods and prairies; common.

340. *M. grandiflora* (Walt.) Kuntze. (*Desmodium acuminatum* D C.) Common in woods.

LESPEDEZA Michx.

341. *L. capitata* Michx. Frequent on prairies.

342. *L. leptostachya* Engelm. Frequent on dry prairies but rapidly disappearing.

VICIA L.

343. *V. americana* Muhl. Pea Vine. Woods and prairies; very common.

LATHYRUS L.

344. *L. venosus* Muhl. Wild Pea. Woods and prairies; common.

345. *L. palustris* L. Rare in low ground; Armstrong.

346. *L. ochroleucus* Hook. Rare; woods west of Estherville.

FALCATA Gmel.

347. *F. comosa* (L) Kuntze. Hog Pea-nut. Woods and prairies; common. The flowers above ground often produce fruit, while the pea-nuts by which the plant is usually propagated, are produced by underground, cleistogamous flowers.

APIOS Moench.

348. *A. apios* (L.) Mac M. A handsome plant, sometimes called False Wisteria, bearing edible tubers. Frequent along river banks, climbing over bushes.

STROPHOSTYLES Ell.

349. *S. helvola* (L.) Britton. (*S. augulosa* Ell; *Phaseolus diversifolius* Pers.) River banks near Armstrong; rare.

350. *S. pauciflora* (Benth.) S. Watson. (*Phaseolus pauciflorus* Benth.) Sandy shore of Swan Lake; rare.

OXALIDACEÆ.

OXALIS L.

351. *O. violacea* L. Violet Wood-sorrel. Woods and prairies; very common.

352. *O. stricta* L. (*O. corniculata* var. *stricta* Sav.). Yellow Wood-sorrel. Very common.

LINACEÆ.

LINUM L.

353. *L. sulcatum* Riddell. Wild Flax. Frequent on dry prairies.

354. *L. usitatissimum* L. Flax. Escaped from cultivation to roadsides, where it persists for a year or two.

RUTACEÆ.

XANTHOXYLUM L.

355. *X. americanum* Mill. Prickly Ash. A prickly shrub, frequent in woods.

POLYGALACEÆ.

POLPGALA L.

356. *P. verticillata* L. Frequent on low prairies.

357. *P. viridescens* L. (*P. sanguinea* L.) Very rare; prairies near Armstrong.

EUPHORBIACEÆ.

ACALYPHA L.

358. *A. virginica* L. Common in the woods south of Iowa Lake.

EUPHORBIA L.

359. *E. glyptosperma* Engelm. Spurge. Very common on dry prairies.

CALLITRICHACEÆ.

CALLITRICHE L.

360. *C. palustris* L. (*C. verna* L.) Slough two miles northeast of Armstrong; also 12 mile Lake, (Prof. B. Shimek 1899.)

ANACARDIACEÆ.

RHUS. L.

361. *R. hirta* (L.) Sudw. (*R. typhina* L.) Stag-horn Sumac. A beautiful shrub, rare in this region. Bank of west fork of Des Moines two miles southwest of Armstrong, and on south shore of Iowa lake.

362. *R. glabra* L. Smooth Sumac. Very common around timber.

363. *R. radicans* L. Poison Oak; Poison Ivy. Very common in woods, and frequent on gopher knolls on prairies. The climbing form does not occur here.

CELASTRACEÆ.

EUONYMUS L.

364. *E. atropurpureus* Jacq. Wahoo; Burning Bush. Rare, in woods along the west fork of the Des Moines.

CELASTRUS L.

365. *C. scandens* L. Climbing Bittersweet. Common in woods and introduced by birds into artificial groves.

STAPHYLEACEÆ.

STAPHYLEA L.

366. *S. trifolia* L. Bladder-nut. A pretty shrub; rare in woods west of Estherville.

ACERACEÆ.

ACER L.

367. *A. saccharinum* L. (*A. dasycarpum* Ehrh.) Soft Maple. Frequent on river banks, and very common in cultivation.

368. *A. nigrum* Michx. (*A. saccharinum* var. *nigrum* Torr. and Gray.) Hard or Sugar Maple. Common in woods, preferring dryer ground than the preceding species.

BALSAMINACEÆ.

IMPATIENS L.

369. *I. biflora* Walt. (*I. fulva* Nutt.) Spotted Touch-me-not. Springy places in woods.

370. *I. aurea* Muhl. (*I. pallida* Nutt.) Pale Touch-me-not. With the preceding, and more common.

RHAMNACEÆ.

CEANOTHUS L.

371. *C. americanus* L. New Jersey Tea. A pretty shrub, frequent on dry prairies.

VITACEÆ.

VITIS L. Wild Grape.

372. *V. vulpina* L. (*V. riparia* Michx.) Very common in woods and artificial groves.

PARTHENOCISSUS Planch.

373. *P. quinquefolia* (L.) Planch. (*Ampelopsis quinquefolia* Michx.) Virginia Creeper. Common in woods, and also in cultivation.

TILIACEÆ.

TILIA L. Basswood.

374. *T. americana* L. Common in low woods. The sweet scented flowers much frequented by bees.

MALVACEÆ.

MALVA L.

375. *M. sylvestris* L. High Mallow. Streets of Estherville; adventive from Europe.

376. *M. rotundifolia* L. Running Mallow. Streets of Estherville; introduced from Europe.

HIBISCUS L.

377. *H. trionum* L. Bladder Ketmia. Venice Mallow. Rarely escaped from cultivation; a native of southern Europe.

HYPERICACEÆ.

HYPERICUM L.

378. *H. canadense* L. Rare in wet places.

TRIADENUM Raf.

379. *T. virginicum* (L.) Raf. (*Elodea campanulata* Pursh.) Common in marshes.

CISTACEÆ.

HELIANTHEMUM Pers.

380. *H. canadense* (L.) Michx. Frostweed. Very rare on gravelly banks.

VIOLACEÆ.

VIOLA L.

381. *V. pedatifida* Don. (*V. delphinifolia* Nutt.) Prairie Violet. Common on dry prairies.

382. *V. obliqua* Hill. (*V. cucullata* Ait.) Meadow Violet. Very common in low ground; variable.

383. *V. pubescens* Ait. Yellow Violet. Common in woods.

LYTHRACEÆ.

LYTHRUM L.

384. *L. alatum* Pursh. Very common in low ground.

ONAGRACEÆ.

LUDWIGIA L.

385. *L. polycarpa* Short and Peter. Low ground near Armstrong; rare.

CHAMÆNERION Adans.

386. *C. angustifolium* (L.) Scop. (*Epilobium angustifolium* L. Willow-herb. Very rare; collected but once in low ground one mile northeast of Armstrong.

EPILOBIUM L.

387. *E. lineare* Muhl. Frequent in low, marshy places.
388. *E. coloratum* Muhl. With the preceding, and more common.

ONAGRA Adans.

389. *O. biennis* (L.) Scop. (*Œnothera biennis* L.) Evening Primrose. Common on prairies, and as a weed in cultivated fields.

MERIOLIX Raf.

390. *M. serrulata* (Nutt.) Walp. (*Œnothera serrulata* Nutt.) Frequent on dry knolls.

CIRCÆA L.

391. *C. lutetiana* L. Frequent in woods.

HALORAGIDACEÆ.

MYRIOPHYLLUM L. Water Milfoil.

392. *M. spicatum* L. Common in lakes and ponds.
393. *M. heterophyllum* Michx. Ponds and streams; less common than the preceding.

ARALIACEÆ.

ARALIA L.

394. *A. racemosa* L. American Spikenard. Frequent in low woods.
395. *A. nudicaulis* L. Wild Sarsaparilla. Rare in the woods along the west fork of the Des Moines.

APIACEÆ.

HERACLEUM L.

396. *H. lanatum* Michx. Cow Parsnip. Infrequent in woods.

PASTINACA L. Parsnip.

397. *P. sativa* L. Escaped from gardens; a native of Europe.

THASPIUM Nutt.

398. *T. trifoliatum aureum* (Nutt.) Britton. (*T. aureum* Nutt.) Meadow Parsnip. Woods west of Estherville.

ERYNGIUM L.

399. *E. aquaticum* L. (*E. yuccæfolium* Michx.) Rattle-snake Master. Very common on prairies.

SANICULA L.

400. *S. canadensis* L. Snakeroot. Common in woods.

PIMPINELLA L.

401. *P. integerrima* (L.) A. Gray. Woods, Iowa lake, infrequent.

WASHINGTONIA Raf. Sweet-Cicely.

402. *W. claytoni* (Michx.) Britton (*Osmorrhiza brevistylis* D C.) Frequent in rich woods.

SIUM L.

403. *S. cicutæfolium* Gmel. Common in sloughs, and margins of ponds.

ZIZIA Koch.

404. *Z. aurea* (L.) Koch. (*Thaspium aureum* var. *apterum* A. Gray.) Meadow-parsnip. Very common on low prairies.

405. *Z. cordata* (Walt.) D C. (*Thaspium trifoliatum* var. *apterum* A. Gray.) Frequent on dry prairies.

CARUM L. Caraway.

406. *C. carui* L. Adventive from Europe.

CICUTA L.

407. *C. maculata* L. Water Hemlock. Common in low ground; the tuberous roots are very poisonous.

408. *C. bulbifera* L. Rare in marshes. This plant bears numerous clusters of bulblets in the leaf axils.

CORNACEÆ.

CORNUS L.

409. *C. circinata* L'Her. Round-leaved Dogwood. Rare on shaded banks.

410. *C. asperifolia* Michx. Infrequent.

411. *C. stolonifera* Michx. Frequent in low woods and on river banks.

422. *C. candidissima* Marsh. (*C. paniculata* L'Her.) Panicled Dogwood. Our commonest species.

413. C. *alternifolia* L. f. Alternate-leaved Dogwood. Rare; woods southwest of Armstrong.

PRIMULACEÆ.

STEIRONEMA Raf. Loosestrife.

414. *S. ciliatum* (L.) Raf. (*Lysimachia ciliata* L.) Woods and prairies; common.

415. *S. lanceolatum* (Walt.) A. Gray. (*Lysimachia lanceolata* Walt.) Rare; in low ground; sometimes growing in water.

416. *S. quadriflorum* (Sims.) Hitch. (*Lysimachia longifolia* Pursh; *Steironewa longifolium* A. Gray.) Very common on low prairies.

NAUMBURGIA Mœnch.

417. *N. thyrsiflora* (L.) Duby. (*Lysimachia thyrsiflora* L.) Tufted Loosestrife. Common in marshes.

OLEACEÆ.

FRAXINUS L.

418. *F. americana* L. White Ash. Very common in low woods, and along streams.

GENTIANACEÆ.

GENTIANA L. Gentian.

419. *G. detonsa* Rottb. Collected but once in low ground near Armstrong.
420. *G. quinquefolia occidentalis* (A. Gray) Hitchcock Rare in woods near Estherville.
421. *G. puberula* Michx. Frequent on rather high prairies.
422. *G. andrewsii* Griseb. Low ground; our commonest species.

MENYANTHACEÆ.

MENYANTHES L. Buck Bean.

423. *M. trifoliata* L. Frequent in bogs.

APOCYNACEÆ.

APOCYNUM L. Dogbane.

424. *A. androsæmifolium* L. Common in woods branches widely spreading.
425. *A. cannabinum* L. Common in woods and on low prairies.

ASCLEPIADACEÆ.

ASCLEPIAS L.

426. *A. tuberosa* L. Pleurisy-root. Common on dry prairies.
427. *A. incarnata* L. Swamp Milkweed. Common in low ground.
428. *A. sullivantii* Engelm. Frequent on low prairies.
429. *A. syriaca* L. (*A. cornuti* L.) Common Milkweed or Silkweed. Common near woods.
430. *A. speciosa* Torr. Showy Milkweed. Common on prairies, where it takes the place of the preceding species which has much smaller flowers.
431. *A. ovalifolia* Decaisne. Dry woods and prairies; frequent.

432. *A. verticillata* L. Open woods and prairies; frequent.

ACERATES Ell.

433. *A. lanuginosa* (Nutt.) Decaisne. Frequent on high prairies.

CONVOLVULACEÆ.

CONVOLVULUS L.

434. *C. sepium* L. (*Calystegia sepium* R. Br.) Wild Morning-Glory. Woods and prairies; very common and troublesome in cultivated fields.

CUSCUTACEÆ.

CUSCUTA L. Dodder.

435. *C. arvensis* Beyr. Parasitic on Artemisia on a dry knoll east of Armstrong.

436. *C. polygonorum* Engelm. (*C. chlorocarpa* Engelm.) Iowa Lake; common on various tall herbs.

437. *C. cephalanthi* Engelm. (*C. tenuiflora* Engelm.) South of Iowa Lake; the last three species determined by Prof. B. Shimek.

438. *C. paradoxa* Raf. (*C. glomerata* Choisy.) Our commonest species, looking like rope wound round tall herbs.

POLEMONIACEÆ.

PHLOX L. Phlox; Wild Sweet William.

439. *P. pilosa* L. Very common; woods and prairies. The flowers occasionally pure white,

440. *P. divaricata* L. Very common in woods.

HYDROPHYLLACEÆ.

HYDROPHYLLUM L.

441. *H. virginicum* L. Water-leaf. Common in low woods.

MACROCALYX Trew.

442. *M. nyctelea* (L) Kuntze. (*Ellisia nyctelea* L.) Common in low woods.

BORAGINACEÆ.

LAPPULA. Mœnch. Stickseed.

443. *L. lappula* (L.) Barst. (*Echinospernum lappula* Lehm.) Common in waste places; naturalized from Europe.

444. *L. virginiana* (L.) Greene. (*Echinospermum virginicum* Lehm; *Cynoglossum morisoni* D C.) Woods and thickets; common.

LITHOSPERMUM L.

445. *L. canescens* (Michx.) Lehm. Hoary Puccoon. Indian Paint-root. Very common.

446. *L. angustifolium* Michx. Rather rare; in dry ground, river banks and shores of lakes.

ONOSMODIUM Michx.

447. *O. carolinianum* (Lam.) D C. False Gromwell Woods and prairies; common.

VERBENACEÆ.

VERBENA L. Verbena.

448. *V. urticifolia* L. Common.

449. *V. hastata* L. Common in dry ground.

450. *V. stricta* L. Our commonest species on dry prairies.

LABIATÆ.

TEUCRIUM L.

451. *T. canadense* L. Wood-sage. Frequent in woods.

452. *T. occidentale* A. Gray. Common on low prairies and in bogs.

SCUTELLARIA L. Skull-cap.

453. *S. lateriflora* L. Common along streams.

454. *S. parvula* Michx. Frequent on low prairies.

455. *S. galericulata* L. Very common in marshes, especially around old muskrat houses.

AGASTACHE Clayt. Giant Hyssop.

456. *A. scrophulariæfolia* (Willd.) Kuntze. (*Lophanthus scrophulariæfolius* Benth.) Frequent in woods.

457. *A. anethiodora* (Nutt.) Britton. (*Lophanthus anisatus* Benth.) Rare in woods along West Fork of Des Moines.

NEPETA L. Catnip.

458. *N. cataria* L. Introduced from Europe into waste places.

PHYSOSTEGIA Benth.

459. *P. virginiana* (L.) Benth. Common along streams.

LEONURUS L.

460. *L. cardiaca* L. Motherwort. Frequent as a weed in waste places; introduced from Europe.

STACHYS L.

461. *S. palustris* L. Common in swamps and on low prairies.

MONARDA L.

462. *M. fistulosa* L. Wild Bergamot. Very common; woods and dry prairies.

KŒLLIA Mœnch.

463. *K. virginiana* (L.) MacM. (*Pycnanthemum lanceolatum* Pursh.) Everywhere common; woods and low prairies.

LYCOPUS L.

464. *L. virginicus* L. Common in marshes. Aerial stolons from tips of fruiting branches observed in this species.

465. *L. americanus* Muhl. (*L. europæus* var. *sinuatus* A. Gray.) Common in low ground.

MENTHA L.

466. *M. canadensis* L. Wild Mint. Frequent in low ground.

SOLANACEÆ.

PHYSALIS L. Ground Cherry.

467. *P. lanceolata* Michx. Common on prairies and in cultivated ground.

468. *P. virginiana* Mill. Similar situations to the preceding, and more common.

SOLANUM L.

469. *S. nigrum* L. Black Nightshade. Very common; the fruit sometimes used for pies.

470. *S. rostratum* Dunal. Rare; three miles south of Armstrong; introduced from the southwest.

DATURA L.

471. *D. stramonium* L. Jimson weed. Infrequent, waste places; introduced from the tropics.

SCROPHULARIACEÆ.

VERBASCUM L.

472. *V. thapsus* L. Great Mullen. State line, Iowa Lake, rare; naturalized from Europe.

SCROPHULARIA L. Figwort.

473. *S. marylandica* L. Woods and prairies; common.

474. *S. leporella* Bicknell. Woods west of Estherville. (Prof. T. J. Fitzpatrick.)

MIMULUS L.

475. *M. ringens* L. Monkey-flower. Frequent along river banks and in low woods.

GRATIOLA L.

476. *G. virginiana* L. Common on low prairies.

ILYSANTHES Raf.

477. *I. gratioloides* (L.) Benth. Low ground near railroad bridge south of Estherville; rare.

VERONICA L.

478. *V. anagallis-aquatica* L. Water Speedwell. Frequent along streams.

LEPTANDRA Nutt.

479. *L. virginica* (L.) Nutt. (*Veronica virginica* L.) Culver's-root. Common; woods and prairies.

GERARDIA L. Gerardia.

480. *G. aspera* Dougl. Frequent on dry prairies.

481. *G. purpurea* L. Rare on low prairies near Armstrong.

482. *G. tenuifolia* Vahl. Common in low ground.

483. *G. auriculata* Michx. Infrequent on prairies.

CASTILLEJA Mutis.

484. *C. sessiliflora* Pursh. Painted-cup. Dry hillsides; becoming scarce.

PEDICULARIS L. Lousewort.

485. *P. lanceolata* Michx. Low prairies; less common than the following:

486. *P. canadensis* L. Low woods and prairies; very common.

PINGUICULACEÆ.

UTRIULARIA L. Bladderwort.

487. *U. vulgaris* L. Common in swamps.

488. *U. intermedia* Hayne. Rare in a marsh one mile east of Armstrong; a most beautiful little plant.

489. *U. minor* L. Very rare in a marsh one and a half miles northeast of Armstrong.

OROBANCHACEÆ.

THALESIA Raf.

490. *T. uniflora* (L.) Britton. (*Aphyllon uniflorum* Torr. & Gray.) North shore of "Weller Lake," Armstrong Grove township; very rare.

PHRYMACEÆ.

PHRYMA L.

491. *P. leptostachya* L. Lopseed. Common in woods, and introduced into artificial groves.

PLANTAGINACEÆ.

PLANTAGO L. Plantain.

492. *P. major* L. Dooryards and waste places. Probably introduced from Europe.

493. *P. rugelii* Decaisne. Growing with the last. Indigenous to America, but undoubtedly introduced here. This plant or the preceding was known to the Indians as White Man's Foot.

494. *P. purshii* R. and S. (*P. patagonica* var. *gnaphalioides* A. Gray.) Rare in dry soil east of Estherville.

RUBIACEÆ.

GALIUM L.

495. *G. boreale* L. Northern Bedstraw. Common near timber.

496. *G. triflorum* L. Frequent in woods.

497. *G. tinctorium* L. (*G. trifidum* Auc.) Low prairies; very common.

498. *G. trifidum* L. (*G. trifidum* var. *pusillum* A. Gray.) Rare in marshes.

499. *G. concinnum* Torr. and Gray. Shining Bedstraw. common in woods.

VIBURNACEÆ.

SAMBUCUS L.

500. *S. canadensis* L. Black Elderberry. Frequent near timber, and along streams. Sometimes cultivated.

VIBURNUM L.

501. *V. pubescens* (Ait.) Pursh. Downy-leaved Arrowwood. Rare in dry woods along west fork of the Des Moines.

502. *V. lentago* L. Black Haw. Common in open woods and along streams. The black edible fruit ripe in September.

TRIOSTEUM L.

503. *T. perfoliatum* L. Rare; in low woods.

SYMPHORICARPOS Juss.

504. *S. occidentalis* Hook. Wolf-berry. Very common; margins of woods, along streams and gopher mounds on open prairies.

LONICERA L.

505. *L. dioica* L. (*L. glauca* Hill.) Bush Honeysuckle. Frequent in woods.

CUCURBITACEÆ.

MICRAMPELIS Raf. Wild Balsam-apple.

506. *M. lobata* (Michx.) Greene. (*Echinocystis lobata* Torr & Gray.) Common in woods and along streams, climbing over low bushes.

CAMPANULACEÆ.

CAMPANULA L.

507. *C. aparinoides* Pursh. Marsh Bellflower. Frequent in marshes.

508. *C. americana* L. Tall Bellflower. Frequent in low woods.

LOBELIA L.

509. *L. syphilitica* L. Great Lobelia. Common on low prairies.

510. *L. spicata hirtella* A. Gray. Very common on low prairies.

CICHORIACEÆ.

TARAXACUM Hall.

511. *T. taraxacum* (L.) Karst. (*T. dens-leonis* Desf.; *T. officinale* Weber.) Common, but probably introduced.

SONCHUS L.

512. *S. asper* (L.) All. Streets of Armstrong; adventive from Europe.

LACTUCA L.

513. *L. scariola* L. A native of Europe, and but lately introduced into our country.

514. *L. ludoviciana* (Nutt.) D C. Common on low prairies. The pinkish flowers rarely opening.

515. *L. pulchella* (Pursh) D C. A recent introduction from the Northwest.

LYGODESMIA D. Don.

516. *L. juncea* (Pursh.) Don. Frequent on dry knolls.

NOTHOCALAIS Greene.

517. *N. cuspidata* (Pursh) Greene. (*Troximon cuspidatum* Pursh.) Frequent on hillsides, especially near streams.

HIERACIUM L. Hawk-weed.

518. *H. canadense* Michx. Woods west of Estherville; infrequent.

NABALUS Cass.

519. *N. albus* (L.) Hook. (*Prenanthes alba* L.) Rare; woods along west fork of Des Moines.

520. *N. asper* (Michx.) Torr. and Gray. (*Prenanthes aspera* Michx.) Frequent on prairies.

521. *N. racemosus* (Michx.) D C. *Prenanthes racemosa* Michx. Frequent on prairies.

AMBROSIACEÆ.

IVA L.

522. *I. xanthiifolia* (Fresen.) Nutt. A troublesome weed in rich ground; introduced from the Northwest about 1870.

AMBROSIA L.

523. *A. trifida* L. Great Ragweed. Very common; woods and waste places.

524. *A. artemisiæfolia* L. Common Ragweed. A very common and troublesome weed.

XANTHIUM L.

525. *X. canadense* Mill. Cockle-bur. Common along streams and introduced into cultivated fields.

CARDUACEÆ.

VERNONIA Schreb.

526. *V. fasciculata* Michx. Iron-weed. Common in low ground.

EUPATORIUM L.

527. *E. purpureum* L. Trumpet-weed. Frequent in woods along west fork of Des Moines.

528. *E. ageratoides* L. f. White Snakeroot. Very common in woods.

529. *E. perfoliatum* L. Boneset. Common; low places, woods and prairies.

KUHNIA L.

530. *K. eupatorioides* L. Dry knolls and river banks; common.

LACINARIA Hill. Blazing Star. Button Snakeroot.

531. *L. punctata* (Hook.) Kuntze. (*Liatris punctata* Hook.) Frequent on dry gravelly knolls.

532. *L. pycnostachya* (Michx.) Kuntze. (*Liatris pycnostachya* Michx.) Very common on low prairies; rarely pure white flowers are seen.

533. *L. scariosa* (L.) Hill. (*Liatris scariosa* Willd.) Common. The heads are usually sessile, but in wet years they are frequently on peduncles an inch or more in length, a form called var. *racemulosa* Sheldon.

SOLIDAGO L. Golden-rod.

534. *S. flexicaulis* L. (*S. latifolia* L.) Frequent in woods.

535. *S. rigidiuscula* (Torr. and Gray.) Porter. (*S. speciosa* var. *angustata* A. Gray.) Rare on dry prairies, growing in clumps.

536. *S. serotina* Ait. Frequent, especially near timber; our tallest species.

537. *S. missouriensis* Nutt. Very common on prairies; our earliest species in flower.

538. *S. canadensis* L. Very common and variable.

539. *S. nemoralis* Ait. Common on dry prairies and gravelly knolls.

540. *S. rigida* L. Very common.

541. *S. riddellii* Frank. Rare on low prairies. The peculiar, grass-like leaves at once distinguish this beautiful species.

EUTHAMIA Nutt.

542. *E. graminifolia* (L.) Nutt. (*Solidago lanceolata* L.) Frequent in low prairies.

BOLTONIA L'Her.

543. *B. asteroides* (L.) L'Her. Very common on low prairies, often growing in water.

ASTER L. Aster.

544. *A. cordifolius* L. Frequent in woods.

545. *A. novæ-angliæ* L. Very common; our largest flowered species.

546. *A. lævis* L. very common; leaves very smooth, and often glaucous.

547. *A. sericeus* Vent. Common on dry prairies. A very distinct and most beautiful species, with silvery leaves and wiry stems.

548. *A. ptarmicoides* (Nees.) Torr and Gray. Flowers white. Rare; six miles west of Estherville on road to Spirit Lake.

549. *A. paniculatus* Lam. Common on low prairies, the leaves resembling those of the Black Willow.

550. *A. lateriflorus* (L.) Britton. (*A. diffusus* Ait; *A. miser* Nutt.) Common in open woods.

551. *A. multiflorus* Ait. Woods and prairies; very common. The flowers, which are very numerous, are white or tinged with purple.

ERIGERON L.

552. *E. philadelphicus* L. Fleabane. Common in low ground.

553. *E. ramosus* (Walt.) B. S. P. (*E. strigosus* Muhl.) Frequent on rather dry prairies.

LEPTILON Raf.

554. *L. canadense* (L.) Britton. (*Erigeron canadensis* L.) Horseweed. A very common weed, especially in waste places.

555. *L. divaricatum* (Michx.) Raf. (*Erigeron divaricatum* Michx.) Rare on prairies near Armstrong.

ANTENNARIA Gærtn. Everlasting.

556. *A. campestris* Rydberg. Very common on prairies.

557. *A. plantaginifolia* (L.) Richards. Open woods. Both species sometimes called Indians' Tobacco.

SILPHIUM L.

558. *S. perfoliatum* L. Indian Cup-plant. Frequent in woods.

559. *S. laciniatum* L. Gum weed; Rosin weed; Compass plant. Common on prairies. The leaves greedily eaten by horses and cattle.

HELIOPSIS Pers. Ox-eye.

560. *H. scabra* Dunal. Woods and prairies; very common.

RUDBECKIA L.

561. *R. hirta* L. Black Eyed Susan. Common on prairies, and in timothy fields as a weed.

RATIBIDA Raf.

562. *R. pinnata* (Vent.) Barnhart. (*Lepachys pinnata* Torr. and Gray.) Very common on dry prairies.

BRAUNERIA Neck.

563. *B. pallida* (Nutt.) Britton. (*Echinacea angustifolia* DC.) Common on dry prairies.

HELIANTHUS L.

564. *H. annuus* L. Common Sunflower. Rare in waste places; introduced from Europe.

565. *H. maximiliani* Schrad. Common on prairies, and as a weed in cultivated fields.

566. *H. grosse-serratus* Martens. Very common in low ground, and our most troublesome species in cultivated fields. All the species of sunflower growing in fields are indiscriminately called rosin-weeds by the farmers.

567. *H. scaberrimus* Ell. (*H. rigidus* Desf.) Very common on dry prairies.

568. *H. strumosus* L. Rare in woods; Iowa Lake and Armstrong Grove.

569. *H. tuberosus* L. Wild Artichoke. Woods and prairies; infrequent.

COREOPSIS L.

570. *C. palmata* Nutt. Tickseed. Common on dry prairies.

BIDENS L.

571. *B. lævis* (L.) B. S. P. (*B. chrysanthemoides* Michx.) Large Bur-marigold. Margins of lakes and ponds; frequent.

572. *B. cernua* L. Smaller Bur-Marigold. Very common in marshes or other wet places; the heads nodding in fruit.

573. *B. frondosa* L. Spanish Needles. Common; a troublesome weed in low fields.

HELENIUM L.

574. *H. autumnale* L. Sneezeweed. Common on low prairies.

ACHILLEA L.

575. *A. millefolium* L. Yarrow. Milfoil. A common and troublesome weed, introduced in grass seed, native to North America as well as Europe and Asia.

ANTHEMIS L. Mayweed.

576. *A. cotula* L. (*Maruta cotula* DC.) Frequent around old dwellings.

ARTEMISIA L. Wormwood.

577. *A. caudata* Michx. Frequent on dry knolls.

578. *A. dracunculoides* Pursh. Woods and prairies; frequent.

579. *A. absinthium* L. Introduced into waste places from Europe.

580. *A. biennis* Willd. Very common, especially as a weed in wet fields.

581. *A. gnaphalodes* Nutt. (*A. ludoviciana* Nutt. var. *gnaphalodes* Torr. & Gray.) Woods and prairies; very common.

ERECHTITES Raf.

582. *E. hieracifolia* (L.) Raf. Fire-weed. Rare in cultivated ground; probably introduced into our county.

MESADENIA Raf.

583. *M. tuberosa* (Nutt.) Britton. (*Cacalia tuberosa* Nutt.) Common on prairies.

SENECIO L.

584. *S. aureus* L. Golden Ragwort. Squaw-weed. Frequent on prairies, usually growing in patches.

585. *S. palustris* (L.) Hook. Occasionally appearing in marshes and around lakes.

ARCTIUM L.

586. *A. lappa* L. Burdock. Waste places; introduced from Europe.

CNICUS L.

587. *C. iowensis* Pammel. Our commonest thistle; woods and prairies.

588. *C. iowensis crattyi* Pammel. Woods and prairies; less common than the species. For a description of this and the preceding, see Proc. Iowa Acad. Sciences, VIII, p. 231.

589. *C. canescens* (Nutt.) Pammel. (*C. undulatus* var. *canescens* Gray; *Cirsium canescens* Nutt.) A perennial thistle growing in patches, and becoming more plentiful.

590. *C. lanceolatus* (L.) Willd. (*Carduus lanceolatus* L.) Common Pasture Thistle. Fields and waste places; naturalized from Europe.

REMARKABLE OCCURRENCE OF AURICHALCITE.

BY CHARLES R. KEYES.

Good aurichalcites are among the rarer specimens in mineral collections. The peculiar feathery habit of crystallization makes the mineral difficult to handle and difficult to preserve even after being collected.

Aurichalcite is a basic carbonate of zinc and copper having, according to Penfield, a chemical formula which should be written 2 (Zn, Cu) Co_3 .3 (Zn, Cu) (OH $_2$.)

The aurichalcite which is here exhibited is from the Graphic Zinc Mines in the Magdalena mountains, in central New Mexico. The noteworthy feature of the occurrence is that the delicate plumose clusters of crystals are preserved by clear crystalline calcite. On this account the rarer mineral is perfectly preserved and is easily handled without danger of destruction.

The single occurrence known in the Graphic mines is of indescribable beauty. A crystal grotto ten or a dozen feet in diameter is entirely lined with exquisite and delicately tinted aurichalcite which is again covered by a thin layer of calcite one-quarter to one-half inch in thickness made up of very perfectly and brightly faceted crystals closely grown together.

Some of the showiest specimens obtained were four to five times the size of a man's head.

CERTAIN BASIN FEATURES OF THE HIGH PLATEAU REGION OF SOUTHWESTERN UNITED STATES.

BY CHARLES R. KEYES.

[ABSTRACT.]

In the Basin region of Western America there exists a remarkable type of intermontane valleys to which the Spanish name Bolson has been given. The geological substructure of these plains has been recently described at some length.* In the present connection some additional features are discussed.

The bolson plains of New Mexico, for example, are found only in that part of the region which belongs to the geographic subdivision known as the basin region. This includes the southern two-thirds of New Mexico, or the portion lying south of the Rocky mountains, which abruptly terminate 100 miles south of the Colorado line. Southward, from this latitude, the bolson plains occur—long level strips of plains country, separated from one another by high but narrow mountain ranges. Far beyond the New Mexican boundaries the same type of physiography prevails, nearly as far as the city of Mexico.

The peculiar alternation of narrow mountain ranges and broad plains presents many features which are not easily understood until the country both to the eastward and to the westward is taken into account. In both directions from the central highland the "perse" character of the basin plains is soon lost.

The different plains become confluent and more continuous, and the mountain ranges more disconnected and

* Am. Jour. Sci., (4), Vol. XV, pp. 207-212, 1903.

finally isolated altogether. Still beyond, the plain alone persists without notable mountains. This condition continues on the one hand to the Gulf of California and on the other to the Gulf of Mexico.

At the beginning of Tertiary time the region between the two great gulfs north to the present Colorado line must have been a vast lowland plain, with but faint relief features. A large part of this plain was on the bevelled edges of Cretaceous and older strata as is shown now in its remnants still clearly discernible. The Las Vegas plateau, the Llano Estacado, the bolson plains of central New Mexico and some of the less broken plains of eastern Arizona seem to belong genetically together. To the east and west of the vast area thus outlined a broad submarine platform was formed from the sediments derived from the planing off of the central land area. When the general bowing up of the region took place later in Tertiary times the great plain formed was partly a peneplane of destructional land origin and partly a constructional plain of marine origin.

After the period of the main uprising, after the whole surface of the country had attained somewhat more than its present elevation above sea-level, normal faulting on a vast scale gave rise to numerous monoclinal block mountains, with a trend of north and south. There were numerous halts in general movement and the Mesozoic and youngest Paleozoic beds here are completely stripped off the mountain summits. Several times the staying process has enabled partial peneplantation to take place. But the mountain blocks have become more and more tilted.

Between Tertiary time and the present, enormous erosion has taken place. The vast plain has been deeply dissected by such old mountain-born streams as the Canadian, Pecos, Rio Grande, and Colorado. The valleys of these water courses are very wide and deep. On the east the Canadian flows 4,000 feet below the level of the old plain. The Pecos perhaps 2,500 feet. The Rio Grande about 1,500 feet. While the Colorado canyon is a mile in depth.

In the Llano Estacado the remnant of the great plain contains 50,000 square miles. The bolson plains are already beginning to give way to erosion agencies. In the valley of the Rio Grande nearly all traces of the old plain are already destroyed. The displaced intermontane basins, like the Jornada del Muerto, which adjoin the long Rio Grande valley are beginning to be deeply dissected wherever the great river touches the borders.

In its broader features the surface of New Mexico may be regarded as a ribbed tableland. Both north and south valleys alternate with long narrow more or less continuous mountain ridges. The most important of the long basin plains and valleys are the Pecos, Huerco, Estancia, Jornada, Rio Grande, San Augustine, and Mimbres.

Over such a surface from the southern end of the Rockies three great streams diverge. These are the Canadian river, the Rio Pecos, and the Rio Grande. The first of these after leaving the mountains flows eastward to the Arkansas in Indian Territory and thence its waters find their way to the Mississippi. Rio Pecos trends southeastwardly, entering Texas near the southeast corner of New Mexico. From the San Luis Valley in Colorado the Rio Grande flows slightly west of south to El Paso. Of these the last two streams mentioned flow in broad valleys between lines of block mountains.

Comparison of physiographic features of basin valleys which the great mountain-born streams traverse and of those which are not so occupied, quickly demonstrates that the bolson owes its existence merely to lack of erosion agencies. The Rio Grande no doubt at first passed through a series of bolsons identical with those at present found on either side of its present valley. It has cut down its channel often 2,000 feet below the surface of the ancient bolsons. Within the valley nearly all traces of the bolson characters are now lost. No waters are received by the great stream after it emerges from the Rockies. The work of this river has been confined to cutting its canyon. Little additional work of side streams has imposed upon it.

A still grander example of its kind is found in the Colorado River of the West. Its great valley, so far below the level of the table land, exists merely because the drainage-way has its source in a region of abundant moisture.

Between the Rio Pecos and Rio Grande valleys at the south end of the Rockies there is a small mountain stream, the Rio Galisteo, which crosses the Estancia bolson, and which soon falls into the Rio Grande. This little stream has carved out a remarkable valley. It is an illustration of how wonderfully effective is even a small, often dry, rivulet in corrading the high plains.

The bolson plains may be considered as sections of an upraised peneplaned surface in its earliest infancy, at a stage in which they are as yet untouched by stream action. They could not exist under present hyprometric conditions except in an arid region, which snow-fed perennial rivers do not traverse. The bolsons are only apparently lake-like basins. They have a marked slope in at least one direction of their major axis, as in the case of the Jornada del Muerto, where the slant is twenty feet to the mile and greater than the gradient of the parallel Rio Grande. Had the latter stream entered at Santa Fe the Estancia-Huerco, or Estancia-Jornada line of bolsons instead of the line to the westward, a vast canyon would have occupied these basins.

The bolson plains of central New Mexico hang high above the great channels of the Rio Pecos and Rio Grande on either side. Were the rainfall of the region sufficient to produce perennial streams the plains would soon be as deeply carved out as the great adjoining valleys of the rivers just mentioned.

NOTE ON THE CARBONIFEROUS FAUNAS OF MISSISSIPPI VALLEY IN THE ROCKY MOUNTAIN REGION.

BY CHARLES R. KEYES.

Recent critical and extensive comparative studies of the Carboniferous faunas of the Rocky mountain region have disclosed some facts that are of great interest to those who have become familiar with the Paleozoic fossils of the Mississippi valley. The Carboniferous faunas of the Continental Interior have now been well understood for over half a century. The faunas of the same geological age from the vast region west of the great central valley of the continent have also been well made out, but for the most part by a group of paleontologists entirely different from that group which was most familiar with the fossils of the Mississippi valley. On this account, chiefly, the faunas of the two regions have been treated largely independently and few exact correlative comparisons made.

Only in a very general way, in the past, have careful correlations been attempted. The results of the recent work are therefore of great significance.

The Rocky mountains abruptly terminate southward soon after crossing the Colorado line. Beyond begins the Mexican tableland with its characteristic basin-range structure. In this part of the southwest the Carboniferous is composed chiefly of a lower calcareous portion and an upper clayey part. The first-named consists of a number of limestone members which attain a thickness of more than 2,000 feet; and represent the Lower Carboniferous limestone, such as is found at Burlington, Iowa, and the limestones of the Upper Coal Measures. No shales of importance nor any beds corresponding to the Lower Coal

Measures of Iowa are known. The second part mentioned is the "Red Beds," which are developed to a thickness of 1,500 feet, clearly of Carboniferous age, and are followed by very similar "Red Beds" which are of Triassic age.

During the past two years I have collected and examined a large variety of fossils from the Carboniferous rocks of New Mexico. My previous acquaintance with the forms of a like age in the Mississippi valley has enabled me to institute some critical comparisons between the faunas of the two regions. The close identity of the two has made a great impression upon me. Forms from the New Mexico region which have been described under strange names have proved to be in reality very old friends. There are relatively a few species that are not common to the two regions.

The conclusions reached in these studies have lately received remarkable corroboration in the results of Girty's studies of the Carboniferous fossils of Colorado.* In this memoir a large synonomy is given. Species after species are identified with Mississippi valley forms. In a very large majority of the forms treated of and discussed the species from Missouri are considered until it would seem that the Missouri reports† could easily have been made the basis of the description of the Colorado species.

The same is true of the New Mexican forms as disclosed by the recent work in this district.

* U. S. Geol. Sur., Professional Papers No. 16, 1903.
† Keyes: Missouri Geol. Sur., Vols. IV and V, 1895.

A PRELIMINARY LIST OF THE FLOWERING PLANTS OF MADISON COUNTY.

BY H. A. MUELLER.

Madison is a prairie county, yet nearly one-fourth of its area was covered at some time, with timber.

The surface, generally speaking, is quite undulating, becoming broken along the courses of the streams. Thus the conditions for a varied flora are favorable, from plants growing on the high prairies to those growing on the timbered hillsides, in the swamps, and along the creeks and rivers.

At the present time the homes of most of our native flowers are limited to the highways and timbered areas on account of the cultivation and pasturage of the land.

The following list of flowering plants was collected during the summers of 1900, 1901, 1902 and 1903. The grasses and sedges have not been studied. The nomenclature followed is that of Gray's Manual, Sixth Edition.

RANUNCULACEÆ. Crowfoot Family.

Clematis virginiana L. Common Virgin's Bower. Not common; rich soil; woods.

C. viorna L. Leather Flower. Rare; river bottoms.

Anemone cylindrica Gray. Long-fruited Anemone. Infrequent.

A. pennsylvanica L. Common on low land.

Hepatica acutiloba DC. Rare; steep hillsides in open woods.

Anemonella thalictroides Spach. Rue-Anemone. Rare.

Ranunculus abortivus L. Small-flowered Crowfoot. Not common.

R. septentrionalis Poir. Very common everywhere.

Isopyrum biternatum Torr & Gray. Low, rich soil in woods; quite common.

Aquilegia canadensis L. Wild Columbine. Very common everywhere in woods.

Delphinium tricorne Michx. Dwarf Larkspur. Frequent.

D. azureum Michx. Prairies.

D. carolinianum. Roadside; not common.

Actæa alba Bigel. White Baneberry. Rare, in woods.

MENISPERMACEÆ. Moonseed Family.

Menispermum canadense L. Moonseed. Not uncommon in rich woods.

BERBERIDACEÆ. Barberry Family.

Podophyllum peltatum L. May Apple. Common in rich woods.

PAPAVERACEÆ. Poppy Family.

Sanguinaria canadensis L. Blood-root. Very common in rich woods.

FUMARIACEÆ. Fumitory Family.

Dicentra cucullaria DC. Dutchman's Breeches. Common in woods.

CRUCIFERÆ. Mustard Family.

Dentaria laciniata Muhl. Toothwort. Frequent in woods.

Nasturtium sinuatum Nutt. Not common.

N. armoracia Fries. Horseradish. Introduced; escaped from cultivation.

Sisymbrium canescens Nutt. Tansy Mustard. Quite common; roadside.

S. officinale Scop. Hedge Mustard. Common along roadside.

Draba caroliniana Walt. Whitlow Grass. Rare. Woods.

Erysimum parviflorum Nutt. Treacle Mustard. Common.

Brassica nigra Koch. Black Mustard. Fields. Introduced.

B. sinapistrum Boiss. Introduced. Common.

Capsella bursa-pastoris Moench. Shepherd's Purse. Very common in waste places.

Lepidium virginicum L. Wild Pepper-grass. Quite common along roadsides.

Raphanussativus L. Common Radish. Escaped from cultivation.

VIOLACEÆ. Violet Family.

Viola pedata L. Bird-foot Violet. Not common. Prairies.

V. pedatifida G. Don. Same as above.

V. palmata L. Common Blue Violet. Very common everywhere.

V. palmata var. *cucullata* Gray. Very common.

V. sagittata Ait. Arrow-leaved Violet. Rare; woods.

V. pubescens Ait. Downy Yellow Violet. Quite common in rich woods.

CARYOPHYLLACEÆ. Pink Family.

Saponaria officinalis L. Soapwort. Bouncing Bet. Infrequent in waste places.

Silene stellata Ait. Starry Campion. Frequent; woods.

Lychnis githago Lam. Corn Cockle. Wheat fields; rare.

PORTULACACEÆ. Purslane Family.

Portulaca oleracea L. Common Purslane. Very common in fields after cultivation.

Claytonia virginica L. Spring Beauty. Quite common in damp, rich woods.

MALVACEÆ. Mallow Family.

Malva rotundifolia L. Common Mallow. Waste places; frequent.

Abutilon avicennæ Gærtn. Velvet Leaf. A troublesome weed in waste places and fields.

Hibiscus trionum L. Bladder Ketmia. Frequent in waste places.

TILIACEÆ. Linden Family.

Tilia americana L. Basswood. Linden. Very common in bottoms and on hill slopes.

LINACEÆ. Flax Family.

Linum usitatissimum L. Common Flax. Escaped from cultivation.

GERANIACEÆ. Geranium Family.

Geranium maculatum L. Wild Cranesbill. Common in rich woods.

G. carolinianum L. Not common.

Oxalis violacea L. Violet Wood-sorrel. Frequent, open woods.

O. *stricta* L. Yellow Wood-sorrel.. Common in woods.

Impatiens pallida Nutt. Pale Touch-me-not. Damp, rich woods along streams.

I. fulva Nutt. Spotted Touch-me-not. Same as above.

RUTACEÆ. Rue Family.

Xanthoxylum americanum. Mill. Northern Prickly Ash. Frequent in woods.

CELASTRACEÆ. Staff Tree Family.

Celastrus scandens L. Wax-work. Climbing Bitter-sweet. Quite common in woods and fence rows.

Euonymus atropurpureus Jacq. Burning-bush. Wahoo. Quite common in the bottoms and along ravines.

RHAMNACEÆ. Buckthorn Family.

Rhamnus lanceolata Pursh. Buckthorn. Frequent in woods.

Ceanothus americanus L. New Jersey Tea. Redroot. Quite common; border of woods and prairies.

VITACEÆ. Vine Family.

Vitis cordifolia Michx. Frost or Chicken Grape. Woods.

V. riparia Michx. Common everywhere in woods and along fence rows.

Ampelopsis quinquefolia Michx. Virginia Creeper. American Ivy. Very common. Fences and woods.

SAPINDACEÆ. Soapberry Family.

Æsculus glabra Willd. Fetid or Ohio Buckeye. Quite common in bottoms.

Acer saccharinum Wang. Sugar or Rock Maple. Common; found in groves on the river bottoms.

A. dasycarpum Ehrh. Soft, or White Maple. Very common along banks of streams.

Negundo aceroides Moench. Ash-leaved Maple. Box-Elder. Common everywhere in rich soils.

Staphylea trifolia L. American Bladder Nut. Rare; hillsides.

ANACARDIACEÆ. Cashew Family.

Rhus glabra L. Smooth Sumac. Common everywhere.

R. toxicodendron L. Poison Ivy. Poison Oak. Common in woods and along fences.

R. radicans L. A shrub 6 to 7 feet high. Rare. Found only one specimen near Drake ford on Middle river.

LEGUMINOSÆ. Pulse Family.

Baptisia leucophæa Nutt. Prairies and open woods. Quite common.

B. leucantha Torr. and Gray. Frequent. Upland and open woods.

Trifolium pratense L. Red Clover. Introduced.

T. reflexum L. Buffalo clover. Rare.

T. stoloniferum Muhl. Running Buffalo Clover. Rare.

T. repens L. White Clover. Everywhere common.

T. hybridum L. Alsike Clover. Not common. Introduced.

Melilotus alba Lam. White Melilot. Sweet Clover. Introduced. Quite common along roadsides.

Medicago sativa L. Alfalfa. Rare. Introduced.

Psoralea tenuiflora Pursh. Frequent; open woods and prairies.

P. melilotoides Michx. Not common.

Amorpha canescens Nutt. Lead Plant. Prairies. Common.

A. fruticosa L. False Indigo. Wet places along sloughs and bottoms. Common.

Petalostemon violaceus Michx. Prairie Clover. Prairies. Frequent.

Tephrosia virginiana Pers. Goat's Rue. Catgut. Uncommon.

Robinia pseudacacia L. Common Locust, or False Acacia. Introduced. Not common.

Astragalus caryocarpus. Ker. Ground Plum. Prairies. Common.

A. canadensis L. Rich soil. Not common.

Desmodium acuminatum DC. Frequent in rich woods.

D. canadense DC. Common in woods.

Lespedeza violacea Pers. Quite frequent in open woods.

L. leptostachya Gray. Quite common on prairies.

Amphicarpæa monoica Nutt. Hog Peanut. Frequent in dry woods.

Cassia marilandica L. Wild Senna. Not common; woods.

Cassia chamæcrista L. Partridge Pea. Very common along waysides in clayey soils.

Gymnocladus canadensis Lam. Kentucky Coffee tree. Not common. Rich soil.

Gleditschia triacanthos L. Three-thorned Acacia, or Honey Locust. Frequent. Woods.

ROSACEÆ. Rose Family.

Prunus americana Marshall. Wild Yellow or Red Plum. Common in thickets.

P. virginiana L. Choke Cherry. Quite common with the plums.

P. serotina Ehrh. Wild Black Cherry. Woods. Common.

Physocarpus opulifolius Maxim. Nine-bark. Frequent along banks of wooded streams.

Rubus occidentalis L. Black Raspberry. Frequent.

R. villosus Ait. Common Blackberry. Common in woods and pastures.

Geum album Gmelin. Frequent.

Fragaria virginiana Mill. Strawberry. Very common in fields and woods.

Potentilla arguta Pursh. Not common.

P. norvegica L. Quite common along roads.

P. canadensis L. Common Cinque-foil, or Five-Finger. Common in meadows and road sides.

Agrimonia eupatoria L. Common Agrimony. Quite common; woods.

Rosa blanda Ait. Smooth Rose. Very common everywhere.

R. arkansana Porter. Prairie Rose. Commom in fields and along fences.

Pyrus ioensis Wood. American Crab Apple. Common in thickets.

P. malus L. Apple. Introduced.

Cratægus coccinea L. Red Haw. Very common in woods and pastures.

C. tomentosa L. Thorn Apple. Not common.

C. crus-galli L. Cockspur Thorn. Infrequent in thickets.

Amelanchier canadensis Torr. and Gray. Shad Bush. Juneberry. Common on steep hillsides and along banks; rocky ravines.

SAXIFRAGACEÆ. Saxifrage Family.

Heuchera villosa Michx. Alum-root. Rare; rocks.

Ribes gracile Michx. Missouri Gooseberry. Common in thickets and river bottoms.

R. aureum Pursh. Golden or Buffalo Currant. Introduced. Dooryards.

LYTHRACEÆ. Loosestrife Family.

Lythrum alatum Pursh. Loosestrife. Fields; common.

ONAGRACEÆ. Evening Primrose Family.

Ludwigia palustris Ell. Water Purslane. Wet places frequent.

Œnothera biennis L. Common Evening Primrose. Common in waste places.

Gaura biennis L. Not common.

Circæa lutetiana L. Enchanter's Nightshade. Woods; common.

CUCURBITACEÆ. Gourd Family.

Echinocystis lobata Torr. & Gray. Wild Balsam Apple. Woods on low ground; frequent.

UMBELLIFERÆ. Parsley Family.

Tiedemannia rigida Coult & Rose. Cowbane. In wild meadows.

Heracleum lanatum Michx. Cow Parsnip. Bottoms; quite frequent.

Pastinaca sativa L. Parsnip. Introduced; escaped from cultivation.

Thaspium aureum Nutt. Woods. Not common.

Pimpinella integerrima Benth. & Hook. Common; woods.

Cicuta maculata L. Spotted Cowbane. Musquash Root. Beaver Poison. Common in wet ground.

Osmorrhiza brevistylis DC. Sweet Cicely. Quite common in woods.

CORNACEÆ. Dogwood Family.

Cornus stolonifera Michx. Red-osier Dogwood. Common in wet places along streams.

C. paniculata L'Her. Panicled Cornel. Thickets; very common.

CAPRIFOLIACEÆ. Honeysuckle Family.

Sambucus canadensis L. Common Elder. Very common in rich bottoms. Troublesome in fields.

Viburnum pubescens Pursh. Downy Arrow-wood. Rocky bluffs; frequent.

V. prunifolium L. Black Haw. Thickets; rare.

Triosteum perfoliatum L. Tinker's Weed. Horse Gentian. Common in open woods.

Symphoricarpos vulgaris Michx. Indian currant. Coralberry. Very common in open woods and along fences. This shrub is becoming troublesome in open timber pastures.

Lonicera sempervirens Ait. Trumpet Honeysuckle. Rare.

L. sullivantii Gray. Sullivant's Honeysuckle. Not common; woods.

RUBIACEÆ. Madder Family.

Cephalanthus occidentalis L. Buttonbush. Ponds; very rare.

Galium aparine L. Cleavers. Goose Grass. Common in damp woods.

G. concinnum Torr. & Gray. Bedstraw. Common; woods.

COMPOSITÆ. Composite Family.

Vernonia fasciculata Michx. Ironweed. Open woods; common.

V. noveboracensis Willd. Same as above.

Eupatorium fœniculaceum Willd. Dog-Fennel. Roadsides and waste places. Very common.

E. ageratoides L. White Snakeroot. Not common; woods.

Liatris pycnostachya Michx. Prairies; quite common.

Solidago ulmifolia Muhl. Golden-rod. Woods; common.

S. rugosa Mill. Border of fields; common.

S. peciosa Nutt. Prairies; not common.

S. canadensis L. Open fields; common.

S. rigida L. Prairies; frequent.

S. lanceolata L. River banks; rich soils; common.

Aster oblongifolius Nutt. Aster.

A. novæ-angliæ L. Prairies and woods; common.

A. novæ-angliæ var. *roseus*. Roadsides on prairies; common.

A. sericeus Vent. Prairies; common.

A. cordifolius L. Woods; frequent.

A. turbinellus Lindl. Hills; common.

A. lævis L. Open woods.

A. amethystinus Nutt. Low grounds; not common.

A. multiflorus Ait. Prairies.

A. dumosus L. Woods; common.

A. diffusus Ait. Woods; common.

A. tradescanti L. Low ground; quite common.

A. salicifolius Ait. Open places; quite common.

A. junceus Ait. Wet places: not common.

Erigeron annuus Pers. Daisy Fleabane. Sweet Scabius. Field and meadows; common.

E. strigosus Muhl. Daisy Fleabane. Same as above.

Antennaria plantaginifolia Hook. Plantain-leaved Everlasting. Dry knolls and woods; common.

Silphium lacinatum L. Rosinweed. Compass plant. Prairies and wild, unbroken meadows in bottoms; frequent.

S. integrifolium Michx. Prairies. Not common.
S. perfoliatum L. Cup-plant. Low grounds. Quite common.
S. terebinthinaceum L. Prairie Dock. Prairies. Not common.
Ambrosia trifida L. Great Ragweed. Waste places. Common.
A. artemisiæfolia L. Roman Wormwood. Hog-weed. Roadsides. Common.
Xanthium canadense Mill. Cocklebur. Fields and waste places. Very common on poorly cultivated farms.
Heliopsis lævis Pers. Woods. Quite common.
H. scabra Dunal. Prairies; frequent.
Echinacea angustifolia DC. Purple Cone flower. Prairies. Quite common.
Rudbeckia laciniata L. Low woods and bottoms. Common.
R. triloba L. Prairies and open woods. Common.
R. hirta L. Same as above.
Lepachys pinnata Torr. & Gray. Prairies; open woods. Common.
Helianthus mollis Lam. Dry grounds; frequent.
H. grosse-serratus Martens. Low land. Common.
H. strumosus L. Borders of woods; frequent.
H. decapetalus L. Low grounds in bottoms. Common.
Actinomeris squarrosa Nutt. Woods; frequent.
Coreopsis palmata Nutt. Prairies and open woods. Common.
C. tripteris L. Tall Coreopsis. Same as above.
Bidens bipinnata L. Spanish Needles. Wet land. Common.
Helenium autumnale L. Sneezeweed. Rich ground; frequent
Achillea millefolium L. Common Yarrow, or Milfoil. Fields and open woods. Very common.
Tanacetum vulgare L. Common Tansy. Waste places; escaped from cultivation.
Artemisia gnaphalodes. Wormwood. Common; waste places.

Senecio aureus L. Golden Ragwort. Squaw-weed. Woods; frequent.

S. aureus var. *balsamitæ* Torr. & Gray. Same as above.

Arctium lappa L. Burdock. Waste places; common; introduced.

Cnicus lanceolatus Hoffm. Common Thistle. Pastures; quite common.

C. altissimus Willd. Rich fields; frequent.

Troximon cuspidatum Pursh. Prairies; rare.

Taraxacum officinale Weber. Common Dandelion. Common everywhere.

Lactuca scariola L. Prickly Lettuce. Waste places; not common.

L. acuminata Gray. Woods; rare.

Sonchus oleraceus L. Common Sow-thistle. Rich ground; frequent.

LOBELIACEÆ. Lobelia Family.

Lobelia syphilitica L. Great Lobelia. Low ground; rare.

L. spicata Lam. High ground; frequent.

CAMPANULACEÆ. Campanula Family.

Specularia perfoliata DC. Venus's Looking-glass. Fields and woods; quite common.

Campanula americana L. Tall Bellflower. Woods; common.

PRIMULACEÆ. Primrose Family.

Steironema ciliatum Raf. Woods; frequent.

OLEACEÆ. Olive Family.

Fraxinus americana L. White Ash. Rich woods; frequent.

F. viridis Michx. f. Green Ash. Border of ponds and wet places; common.

APOCYNACEÆ. Dogbane Family.

Apocynum androsæmifolium L. Spreading Dogbane. Border of thickets; common.

ASCLEPIADACEÆ. Milkweed Family.

Asclepias tuberosa L. Butterfly-weed. Pleurisy-root. Prairies; common.

A. purpurascens L. Purple Milkweed. Dry land; not common.

A. incarnata L. Swamp Milkweed. Wet land; common.

A. cornuti Decaisne. Common Milkweed or Silk-weed. Fields; very common.

A. verticillata L. Woods and fields; quite common.

Acerates viridiflora var. *linearis* Gray. Prairies; common.

GENTIANACEÆ. Gentian Family.

Gentiana andrewsii Griseb. Closed Gentian. Low grounds; rare.

POLEMONIACEÆ. Polemonium Family.

Phlox pilosa L. Prairie Sweet William. Prairies; common.

P. divaricata L. Timber Sweet William. Rich woods; common.

Polemonium reptans L. Greek Valerian. Rich woods; not common.

HYDROPHYLLACEÆ. Waterleaf Family.

Hydrophyllum virginicum L. Woods; common

H. appendiculatum Michx. Damp woods; frequent.

Ellisa nyctelea L. Low damp shady places; common.

BORRAGINACEÆ. Borage Family.

Cynoglossum officinale L. Common Hound's Tongue. Waste places; quite common.

Echinospermum virginicum Lehm. Beggar's Lice. Woods; common.

Mertensia virginica DC. Blue Bells. Lungwort. Virginian Cowslip. Woods; rare. Jefferson township.

Lithospermum canescens Lehm. Puccoon of the Indians. Prairies and woods; very common.

L. hirtum Lehm. Same as above.

Onosmodium carolinianum DC. False Cromwell. Open woods; common.

CONVOLVULACEÆ. Convolvulus Family.

Ipomœa hederacea Jacq. Morning Glory. Waste and cultivated ground; common.

Convolvulus sepium L. Hedge Bindweed. Rich ground; common.

SOLANACEÆ. Nightshade Family.

Solanum nigrum L. Common nightshade. Low ground; not common.

S. carolinense L. Horse Nettle. Fields; rare.

Physalis philadelphica Lam. Ground Cherry. Fields; frequent.

P. lanceolata Michx. Same as above.

Datura stramonium L. Common Stramonium or Thorn Apple. Jamestown Weed. Waste places, about the barnyards; frequent.

SCROPHULARIACEÆ. Figwort Family.

Verbascum thapsus L. Common Mullein. Dry waste places; common.

Linaria canadensis Dumont. Sandy soil; not common.

L. vulgaris Mill. Ramsted. Butter and Eggs. Roadside; not common. Introduced.

Veronica virginica L. Culver's-root. Culver's Physic. Woods; frequent.

V. peregrina L. Neckweed. Purslane Speedwell. Wet places; common.

BIGNONIACEÆ. Bignonia Family.

Catalpa bignonioides Walt. Catalpa. Introduced. Groves.

ACANTHACEÆ. Acanthus Family.

Ruellia ciliosa Pursh. Open woods; common.

VERBENACEÆ. Vervain Family.

Verbena urticæfolia L. White Vervain. Fields and waste places; common.

V. stricta Vent. Hoary Vervain. Fields and open woods; common.

V. bracteosa Michx. Waste places; not common.

LABIATÆ. Mint Family.

Teucrium canadense L. American Germander. Wood Sage. Low grounds; common.

Mentha viridis L. Spearmint. Wet places; common.

M. piperita L. Peppermint. Frequent along streams.

Pycnanthemum linifolium Pursh. Open woods; infrequent.

Hedeoma pulegioides Pers. American Pennyroyal. Open woods; common.

Monarda fistulosa L. Wild Bergamot. Prairies; common.

Nepeta cataria L. Catnip. Waste places. Introduced; common.

N. glechoma Benth. Ground Ivy. Gill-over-the-Ground. Waste places; cemeteries; escaped.

Scutellaria lateriflora L. Mad-dog Skullcap. Woods; common.

S. parvula Michx. Prairies; frequent.

Brunella vulgaris L. Common Self-heal or Heal-all. Open woods; common.

Marrubium vulgare L. Common Horehound. Waste places; quite common. Introduced.

Leonurus cardiaca L. Common Motherwort. Waste places near dwellings; common. Introduced.

PLANTAGINACEÆ. Plantain Family.

Plantago major L. Common Plantain. Roadsides and waste places; common.

NYCTAGINACEÆ. Four-o-clock Family.

Oxybaphus nyctagineus Sweet. Frequent along roadsides.

AMARANTACEÆ. Amaranth Family.

Amarantus albus L. Tumble Weed. Waste grounds; rare.

A. blitoides Watson. Waste places; frequent.

CHENOPODIACEÆ. Goosefoot Family.

Chenopodium album L. Lamb's Quarter. Pigweed. Fields; frequent.

POLYGONACEÆ. Buckwheat Family.

Rumex altissimus Wood. Pale Dock. Rich soils. Quite common.

R. crispus L. Curled Dock. Wayside. Common.

Polygonum aviculare L. Knotweed. Common in yards

P. pennsylvanicum L. Common in wet places.

P. persicarioides. H. B. K. Waste places; quite common.

P. hydropiperoides L. Michx. Mild Water pepper. Wet soil; frequent.

P. hydropiper L. Common Smartweed or Water pepper. Wet land. Common.

P. virginanum L. Woods; frequent.

P. convolvulus L. Black Bindweed. Fields. Common.

P. dumetorum L. var. *scandens* Gray. Climbing False Buckwheat. Moist thickets. Common.

Fagopyrum esculentum Moench. Buckwheat. Escaped from fields.

ARISTOLOCHIACEÆ. Birthwort Family.

Asarum canadense L. Wild Ginger. Hillsides in rich woods. Common.

THYMELAEACEÆ. Mezereum Family.

Dirca palustris L. Leatherwood. Moosewood. Woods; rare.

EUPHORBIACEÆ. Spurge Family.

Euphorbia glyptosperma Engelm. Roadsides; infrequent.

E. heterophylla L. Dry soil; not common.

E. cyparissias L. Cemeteries; escaped from cultivation.

E. corollata L. Open woods. Common.

URTICACEÆ. Nettle Family.

Ulmus fulva Michx. Slippery or Red Elm. Rich upland and bottoms; common.

U. americana L. American or White Elm. Common on river bottoms.

U. racemosa Thomas. Cork or Rock Elm. Not common.

Celtis occidentalis L. Hackberry. Sugarberry. Quite common on bottom land.

Cannabis sativa L. Hemp. Roadsides; escaped from cultivation.

Humulus lupulus L. Common Hop. Thickets; common.

Maclura aurantiaca Nutt. Osage Orange. Introduced; used for hedges.

Morus rubra L. Red Mulberry. Thickets; not common.

Urtica gracilis Ait. Nettle. River banks and fences; common.

Bœhmeria cylindrica Willd. False Nettle. Moist woods; frequent.

PLATANACEÆ. Plane-tree Family.

Platanus occidentalis L. Sycamore. Buttonwood. Along streams; not common.

JUGLANDACEÆ. Walnut Family.

Juglans cinerea L. Butternut. White Walnut. Rich river bottoms; frequent.

J. nigra L. Black walnut. River bottoms; common. Large trees have all been cut.

Carya alba Nutt. Shellbark or Shagbark Hickory. Common on upland.

C. amara Nutt. Bitternut Hickory. Rich woods; common.

C. porcina Nutt. Pignut Hickory. Dry hills and uplands; frequent.

CUPULIFERÆ. Oak Family.

Corylus americana Walt. Wild Hazlenut. Thickets, outskirts of timber and prairies; common.

Ostrya virginica Willd. American Hop-Hornbeam. Ironwood. Steep hillsides; common.

Quercus alba L. White Oak. Common on hills.

Q. macrocarpa Michx. Burr Oak. Over-cup or Mossy-cup Oak. Bottoms and hills; common.

Q. muhlenbergii Engelm. Yellow Oak. Chestnut Oak. Not common.

Q. rubra L. Red Oak. Hills; common.

Q. coccinea Wang. Scarlet Oak. Upland woods. Common.

Q. coccinea Wang. var. *tinctoria* Gray. Black Oak. Upland.

Q. prinoides Willd. Prairies and upland woods; common

Q. marylandica. Muench. Black Jack, a barren Oak. Common on dry clay soils.

SALICACEÆ. Willow Family.

Salix nigra Marsh. Black Willow. Common along river banks.

S. alba L. White Willow. Introduced; common.

S. longifolia Muhl. Sandbar Willow. Low ground; frequent.

S. discolor Muhl. Glaucous or Pussy Willow. Damp ground; not common.

S. humilis Marsh. Prairie Willow. Prairies; frequent.

S. tristis Ait. Dwarf Gray Willow. Hillside thickets; not common.

Populus alba L. White Poplar. Introduced; escaped.

P. tremuloides Michx. American Aspen. Not common. I have found it only on North Branch, Jefferson township.

P. monilifera Ait. Cottonwood. Necklace Poplar. Common along banks of streams.

CONIFERÆ. Pine Family.

Juniperus virginiana L. Red Cedar. Found on hillsides and bluffs of streams; frequent.

ORCHIDACEÆ. Orchis Family.

Habenaria leucophæa Gray. Greenish Fringed-Orchis. Low prairies; rare.

Cypripedium parviflorum Salisb. Smaller Yellow Lady-slipper. Rich woods; once very common, but very rare now.

IRIDACEÆ. Iris Family.

Iris versicolor L. Larger Blue Flag. Ponds; very common.

Sisyrinchium angustifolium Mill. Blue-eyed Grass. Open woods and meadows; common.

AMARYLLIDACEÆ. Amaryllis Family.

Hypoxis erecta L. Star Grass. Prairies and wild meadows; common.

DIOSCOREACEÆ. Yam Family.

Dioscorea villosa L. Wild Yam-root.

LILIACEÆ. Lily Family.

Smilax hispida Muhl. Greenbriar. Woods; frequent.

Allium canadense Kalm. Wild Garlic. Open woods; common.

Polygonatum biflorum Ell. Smaller Solomon's Seal. Woods; frequent.

P. giganteum Deitrich. Great Solomon's Seal. Rich woods; common.

Asparagus officinalis L. Garden Asparagus. Escaped from cultivation.

Smilacina racemosa Desf. False Spikenard. Woods; common.

Uvularia perfoliata L. Bellwort. Rich woods. Common.

Erythronium albidum Nutt. White Dog's-tooth Violet. Woods; common.

Lilium philadelphicum L. Wild Orange-red Lily. Prairies; frequent.

L. canadense L. Wild Yellow Lilly. Not common.

L. tigrinum Ker. Tiger Lily. Escaped from gardens,

Trillium nivale Riddell. Dwarf White Trillium. Steep upland woods; frequent.

COMMELINACEÆ. Spiderwort Family.

Tradescantia virginica L. Common Spiderwort. Fields. prairies and along railroad tracks; common.

TYPHACEÆ. Cat-tail Family.

Typha latifolia L Common Cat-tail. Ponds and boggy places; common.

Sparganium eurycarpum Engelm. Bur-reed. Ponds; frequent.

ARACEÆ. Arum Family.

Arisæma triphyllum Torr. Indian Turnip. Damp woods; common.

Acorus calamus L. Sweet Flag. Calamus. Ponds; frequent.

ALISMACEÆ. Water-Plantain Family.

Sagittaria variabilis Engelm. Arrowhead. Sloughs and ponds; common.

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